AGRICULTURAL ENGINEERING

MAY • 1954

In this Issue . . .

ASAE 47th Annual Meeting • Minneapolis, Minn., June 20-23

ASAE

THE JOURNAL OF THE

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS


AIRCRAFT PRECISION
TRANS WORLD AIRLINES
Original equipment on Constellations since the first model, MECHANICS Roller Bearing UNIVERSAL JOINTS precision meets every aircraft need. Designs, metals, machining, tolerances, heat treating, hardening, balancing and lubrication — all are specifically adapted for aircraft precision. Let MECHANICS universal joint engineers help solve your control and power transmission problems. Catalog, containing helpful universal joint data and tracing kits, sent to engineers upon request.
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2046 Harrison Avenue, Rockford, Illinois
MECHANICS
Roller Bearing
BW
UNIVERSAL JOINTS
For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS • MAY, 1954 • VOL. 35, NO. 5

Note: AGRICULTURAL ENGINEERING is regularly indexed by Engineering Index and by Agricultural Index. Volumes of AGRICULTURAL ENGINEERING, in microfilm form, are available (beginning with Vol. 32, 1951), and inquiries concerning purchase should be directed to University Microfilms, 313 N. First St., Ann Arbor, Michigan.

AGRICULTURAL ENGINEERING is owned and published monthly by the American Society of Agricultural Engineers. The editorial, subscription and advertising departments are at the executive office of the Society, 505 Pleasant St., St. Joseph, Mich. (Telephone: 3-2700).

RAYMOND OLNEY
Editor and Publisher

SUBSCRIPTION PRICE: $4.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $3.00 a year. Single copies (current), 40 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103. Act of October 3, 1917, authorized August 11, 1921.

J. I. Case Portable Elevator utilizes lightweight, economical Steel Link-Belt to elevate ear corn into crib.

For low-cost farm implement drive or conveyor service --

it's STEEL LINK-BELT

LINK-BELT offers the chain that's best for every job

THE many varied farm implement drive and conveying jobs performed by chains and sprockets require different physical characteristics. Steel Link-Belt is an example of how Link-Belt builds a type and size for every purpose.

In addition, every chain in the complete Link-Belt line is built for longer life. Rigid control of raw materials and manufacturing processes is your assurance of greater uniformity.

For all the facts on Steel Link-Belt, ask for Book 2403. And for information on the complete Link-Belt chain line, see your nearest Link-Belt representative.

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices in Principal Cities. 13,331

LINK-BELT

THE SYMBOL OF QUALITY · LINK-BELT

CHAINS AND SPROCKETS

No one chain serves every purpose . . . get the RIGHT one from Link-Belt's complete line

Steel Link-Belt for moderate-strength power transmission and conveying. Also available in malleable.

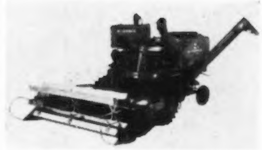
Class 400 Pintle chain—cast links with closed pin joint, for light conveyor, elevator or drive duty.

Double-Pitch Precision Steel Roller Chain, for conveyor, power transmission applications.

Precision Steel Roller Chain, standard pitch, combines high horsepower with light weight.

Complete Link-Belt sprocket line includes single and multiple width sprockets.

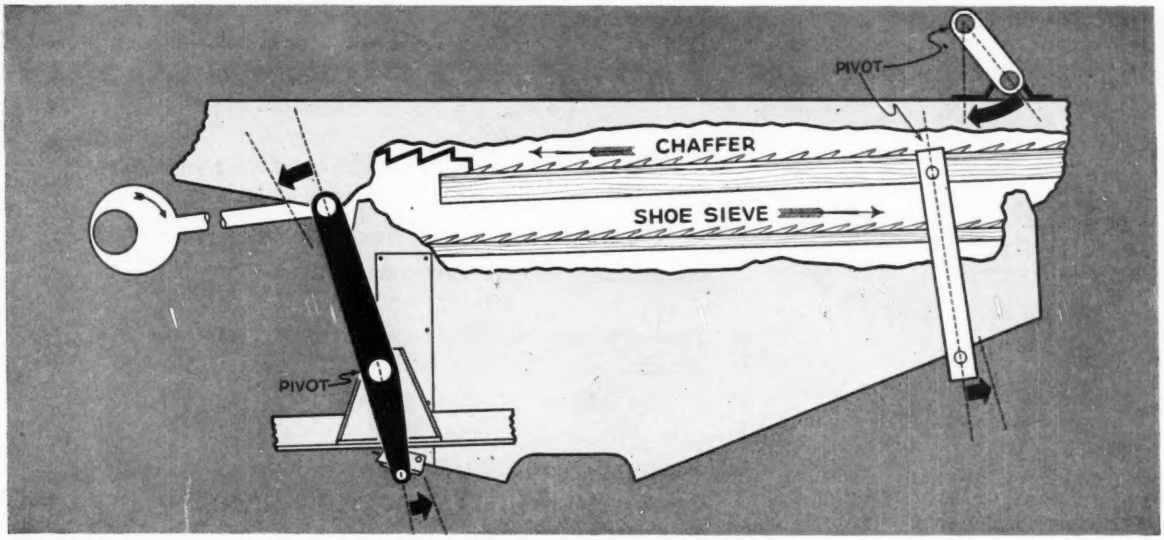
A report to you about men and machines that help maintain International Harvester leadership



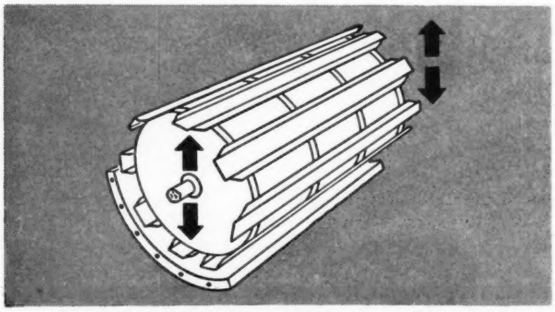
Exclusive opposed-action shoe prevents straw-blocked sieves in the

NEW McCormick® 141 HARVESTER-THRESHER

Over 35 new grain saving features include 60 hp engine, complete redesign to save more of the last 10% of the crop.



In the IH opposed-action shoe, the chaffer goes forward when the shoe sieve moves backward. This eliminates any tendency for the straw particles to bridge and lodge between shoe and sieve. The shoe's full area is always clear to thoroughly clean heaviest yields.



Exclusive *Rigid-Mounted Concave* with quick, two-point cylinder adjustment gives uniform, accurately-held clearance from front to rear and end to end. More efficient threshing and separation at the concave is the result.

OTHER MAJOR IMPROVEMENTS

of the McCormick 141 include:

- redesign of cutting mechanism for more positive feeding of straw
- quick, easy adjustment of cylinder speed and cleaning air blast to meet changing conditions
- improved visibility with faster, easier control for greater operator comfort

IH engineering teamwork produced the added grain-saving features of the new McCormick No. 141 harvester-thresher. IH research, engineering and manufacturing men are constantly pooling their time and talent to solve farm problems—to provide equipment that makes farm work easier and the farmer's time more productive!

INTERNATIONAL HARVESTER

International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors... Motor Trucks... Crawler Tractors and Power Units... Refrigerators and Freezers—General Office, Chicago 1, Illinois

"This Needle Bearing can carry a terrific load"

For its size and weight, the Torrington DC Needle Bearing has a greater rated radial load capacity than *any* other type of anti-friction bearing.

The Needle Bearing is only slightly larger than a plain bearing, yet it delivers efficient anti-friction performance with a minimum of maintenance attention. Its drawn and hardened outer shell, when pressed into a recommended housing bore, serves as the outer race. A full complement of small diameter rollers gives many lines of contact to distribute the load.

Your product can gain many advantages from the Needle Bearing's design and performance. Housings, mountings and other related parts can be made lighter and smaller. Lubrication is needed less frequently since the turned-in lips of the bearing keep lubricants in, dirt out. And you get high capacity anti-friction performance for little more than the price of a plain bearing.

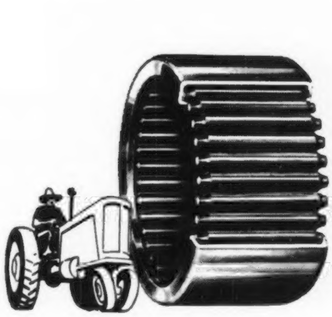
Our Engineering Department will be glad to lend a hand in design analysis and bearing selection.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers



Tractors, harvesters, combines, mowers and many other farm machines produced by leading manufacturers utilize Torrington Needle Bearings to good advantage. In main drives, crankshafts, gearboxes, idler pulleys, steering gears, hydraulic pumps and a host of other assemblies, Needle Bearings take the punishing loads of daily farm use.

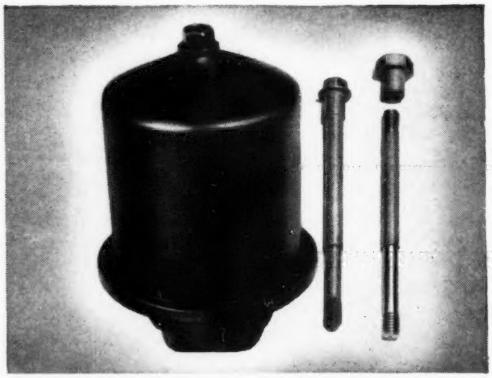
Here's where Purolator screened out rising costs

• Purolator makes oil filters for a prominent auto maker. They're top-notch filters that do a tough job well. Purolator and the car manufacturer are both proud of them.

Not long ago an RB&W "fastener engineer" got loose in the Purolator plant—just when company production executives were looking for a way to lick rising costs. He noticed that the Purolator filter was being assembled with a two-piece fastener made slowly and laboriously on a screw machine.

Our man told the Purolator people about RB&W's batteries of cold-forming machines. Purolator wanted to know more. Now their filter is assembled with a one-piece RB&W fastener that costs far less to make and assemble.

Chances are you can find a stage in your operations where RB&W "fastener engineering" can help you keep costs in line. As a leading manufacturer of all kinds of fasteners, we're always able to recommend and supply the right ones for all your needs. Write RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY, Port Chester, N. Y.

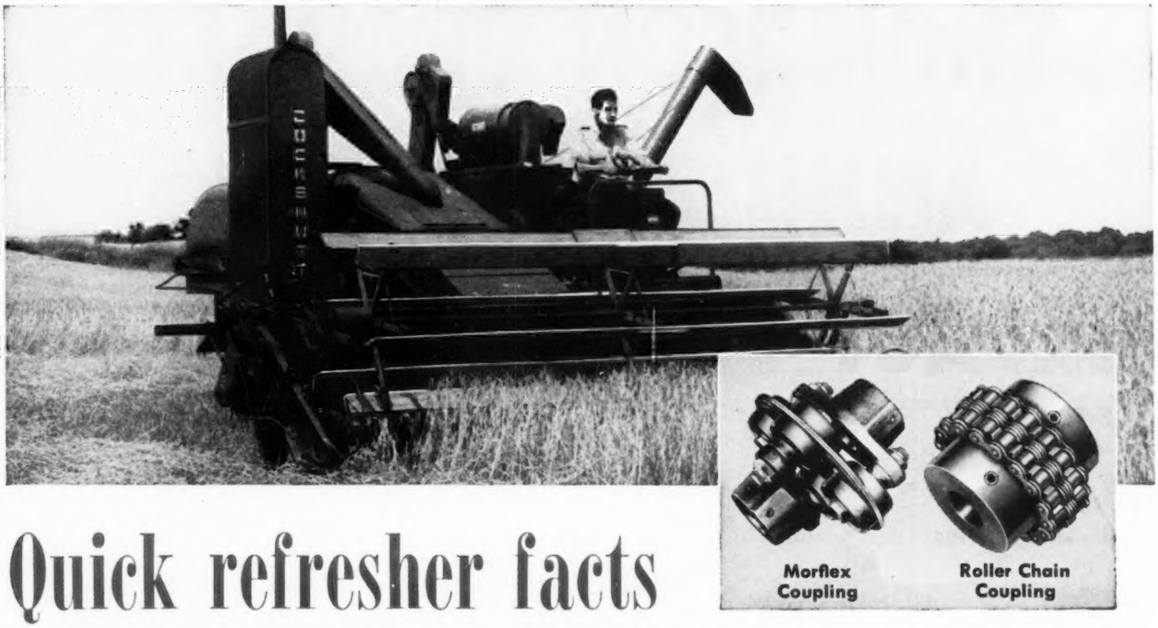


EASIER, FASTER ASSEMBLY undercut high costs when Purolator switched from a two-piece fastener *(right)* to an RB&W-designed cold-formed fastener *(left)* for its famous oil filter.

RB&W

109 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: PORT CHESTER, N. Y., CORAOPOLIS, PA., ROCK FALLS, ILL., LOS ANGELES, CALIF. *Additional sales offices at:* PHILADELPHIA, PITTSBURGH, DETROIT, CHICAGO, DALLAS, SAN FRANCISCO. *Sales agents at:* PORTLAND, SEATTLE. *Distributors from coast to coast.*



Quick refresher facts

ABOUT MORSE FLEXIBLE COUPLINGS

Morse Morflex Couplings

You can save on lubrication and maintenance when you equip your farm machinery with Morflex Flexible Couplings. There are no moving parts to wear out.

Morflex Couplings accommodate all conditions of misalignment and torsional load vibration by elastic deflection of neoprene biscuits. In addition, Morflex Couplings are impervious to water, dirt, oil and weather conditions.

The end result from using the Morse Morflex Coupling is smooth, vibration-free power transmission, without undue thrust loads on drive shaft bearings (even over rough terrain). It also cushions shock loads, prolongs bearing life and assures quiet operation.

Flexible Chain Couplings

The adaptability of chain as a coupling medium provides a versatility of design which simplifies the development of special-purpose couplings. Space limitations and assembly problems are easily solved by the use of these couplings.

The Morse Stock Roller Chain Couplings are of all-steel construction, assuring strength, durability and long, trouble-free service life in minimum space. Consisting of two sprockets and a length of Morse Double Roller Chain, they have increased roller sprocket bearing areas, affording greater horsepower capacity for a given over-all diameter.

Extremely easy to install and align, the flexible chain couplings are compact and allow for slight angular or parallel misalignments.

Morse Standard Flexible Chain Couplings are stocked in a wide range of stock sizes and standard bore diameters, assuring an easy catalog selection for most applications.

Further Information

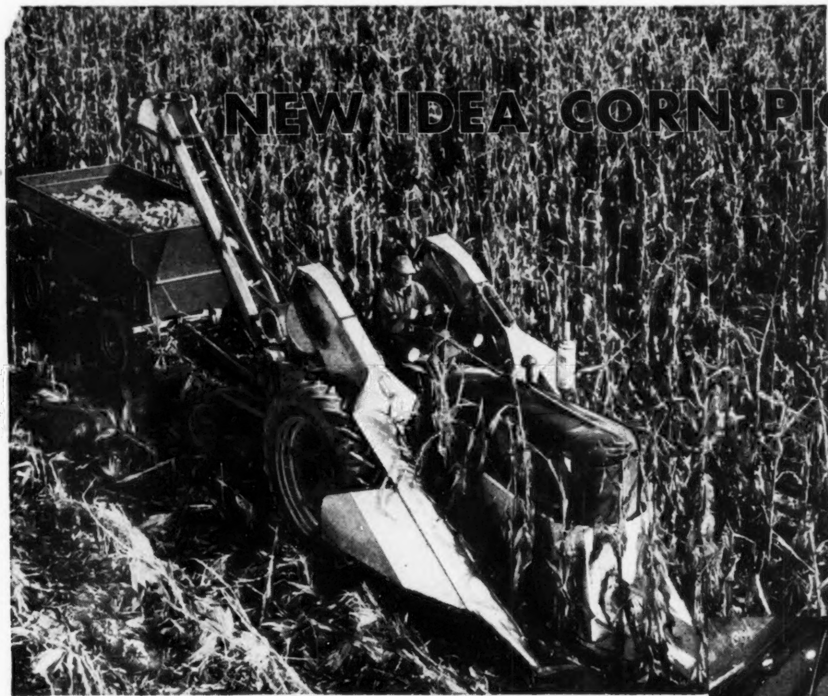
Write today for Catalog C 4148 for information on the Morse Morflex Coupling. For information on the Flexible Chain Coupling, ask for Catalog C 45-49.

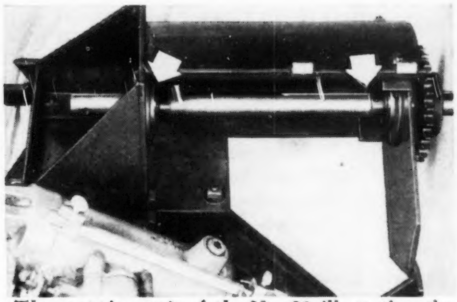
MORSE CHAIN COMPANY
7601 CENTRAL AVENUE • DETROIT 10, MICHIGAN

FOR 24 REASONS, MASTERS OF MECHANICAL POWER TRANSMISSION SINCE 1893

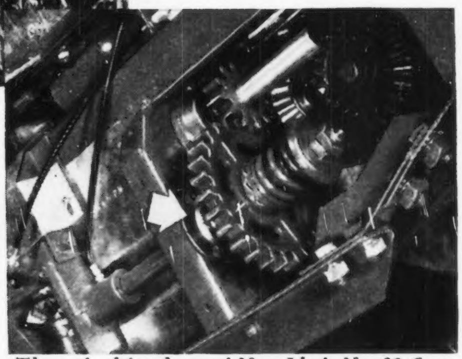
NEW IDEA CORN PICKER

features Popular Idea for Eliminating Friction





The snapping unit of the No. 20 illustrating the use of Fafnir Flangettes



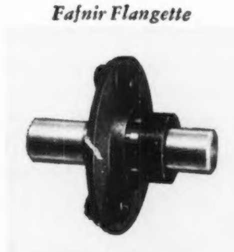
The main drive drum of New Idea's No. 20 Corn Picker illustrating the use of Fafnir Ball Bearing Flangettes

The new No. 20 Two-Row Mounted Corn Picker introduced by New Idea features an extra-large trailing husking bed and rear-mounted caster wheels which bear part of the weight usually imposed on the tractor. Ball bearing-equipped shafts are design advantages which contribute in no small measure to its ability to deliver unusually clean-picked corn.

New Idea design engineers found the precise answer to specific bearing requirements in the low-cost, easy-to-install Fafnir Flangettes. These economy units are complete with pressed steel housings, Fafnir Wide Inner Ring Ball Bearing with self-locking collars and efficient seals. Their application assures long, uninterrupted, trouble-free operation with minimum servicing.

Like New Idea, other manufacturers of farm equipment are turning to Fafnir for precise answers to bearing problems. In addition to a wide selection of bearings, they find most helpful the Fafnir "attitude and aptitude" . . . a way of looking at bearing problems from the designer's viewpoint and the ability to supply the right bearing for the need. Maybe this combination can help you. The Fafnir Bearing Company, New Britain, Conn.

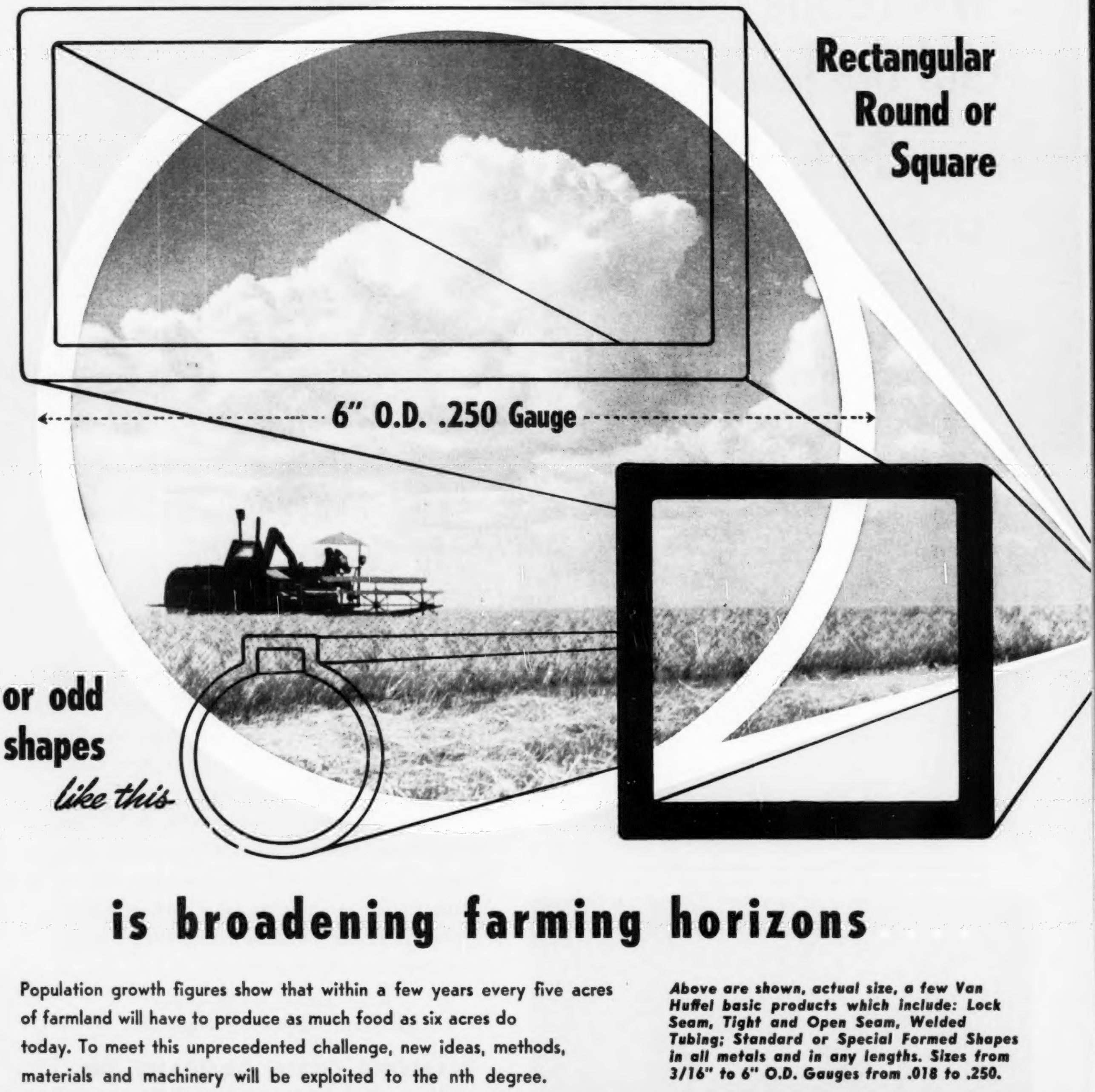
Fafnir Flangette



FAFNIR BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Van Huffel Cold Formed Tubing *like this in*



is broadening farming horizons

Population growth figures show that within a few years every five acres of farmland will have to produce as much food as six acres do today. To meet this unprecedented challenge, new ideas, methods, materials and machinery will be exploited to the nth degree. Maybe now is the time to take a long, hard look at your products with these questions in mind: Can they be made better . . . faster . . . cheaper? Could Van Huffel Cold Formed Tubing be substituted for heavier, more costly materials now being used?

Above are shown, actual size, a few Van Huffel basic products which include: Lock Seam, Tight and Open Seam, Welded Tubing; Standard or Special Formed Shapes in all metals and in any lengths. Sizes from 3/16" to 6" O.D. Gauges from .018 to .250.

Write today for free portfolio of cost reducing ideas that have taken shape in the farm equipment field.

VanHuffel

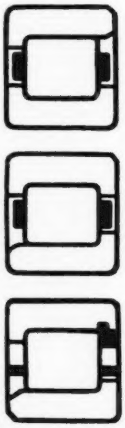
TUBE CORPORATION · WARREN, OHIO

Where ideas take shape for makers of farm equipment

Trying to "Locate" a Shaft?

HERE'S HOW HYATTS HELP...

3 TYPES



Shown in section at the left are three Hyatt Hy-Load Bearing types that are used for axial shaft location. Flanges on inner or outer races limit axial shaft movement and permit the bearing to take light, intermittent thrust loads.

Since Hyatt inner races are assembled on shafts, with relatively heavy press fits, no accessory parts are necessary to hold them in place.

Hyatt Hy-Load Bearings are available with a variety of combinations of race flanges, snap rings, cages or separators, so that just the right combination can be selected for each set of operating conditions.

Hy-Loads are available in three diameter series, two widths and a complete range of sizes. For complete information write for Catalog 150—Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

AGRICULTURAL ENGINEERING

VOL. 35 MAY, 1954 NO. 5

Rationalizing Analysis in Design

Coby Lorenzen
Member ASAE

RESEARCH has become the important spur to progress in all types of enterprise. Several kinds of engineering research have been defined in order to classify the scope of a particular project. One of these, pure or basic research, has the objective of expanding the limits of scientific knowledge. Another, applied research, deals with the analysis of the behavior of systems or components for the purpose of design. This paper is concerned with the latter type, and its aim is to indicate the importance of the systematic approach to solving design problems.

No field presents a greater diversity of problems than does that of agricultural engineering. It covers a great variety of products and involves many different processes in their handling. For these reasons much of the work is accomplished with specialty equipment. Contrasted with the average manufactured article, which is machine handled, many of the products of agriculture have large variations in size and shape, require separation (from a plant on which they have grown, or from the soil), and must be delivered with minimum bruising or damage, which impair market value or storage qualities.

There are several classes of problems. Some may be of a general nature, some basic to a particular process or system, and some may simply be design problems, elementary in themselves but preventing successful operation of a machine.

The approach to a particular problem will, of course, be determined to an extent by its nature. Nevertheless, a general pattern may be devised that will serve as a guide to organized thinking. Developing such a pattern might be done in a few fundamental stages:

- An analytical process that leads to a concise statement of the problem, including a clear definition of its limits.
- Collection of an adequate fund of accurate relevant information.
- Development of a working hypothesis by systematic arrangement of the information.
- A twofold test of the hypothesis—first, to determine progress toward the general solution, and, second, to uncover additional information that may modify the original hypothesis or establish a new one.
- A breakdown of the product developed from this synthesis into its natural elements and separate attacks on the obstacles involved in each.

The experiences of the Department of Agricultural Engineering of the University of California at Davis afford many examples of the different types of problems that confront the worker in developing the kind of machine classed as specialty equipment. Credit is due the members of the department collectively for the examples given. The experimental staff represents a wide range of backgrounds which practically parallel the problems encountered.

In general, engineering is the practice of applying physical laws to a particular problem and arriving at a solution represented by a practical structure, device, or machine. Compromise may be necessary in the process; assumptions made that modify the theory; approximations accepted that produce practical results. However, it is interesting to note how closely many of the modified systems follow the physical laws.

The examples given here illustrate the point. The solutions are not always presented. When they are, they may not be the simplest or best. They do, however, show the types of problems encountered and indicate the thinking involved in seeking solutions.

Mention was made of the simple design problem. An example, which has had many parallels in other machines, is that of the elevator of the mechanical onion harvester. Here the product being handled is one of extreme physical tenderness when first pulled from the ground. The elevator was designed to lift the onion bulbs from a hopper and drop them into sacks. Fig. 1-*a* illustrates the original design, with the elevator flights mounted above the conveyor line. During the straight portion of the transport, the velocities of conveyor and all points of the flights are constant. At the top there is a

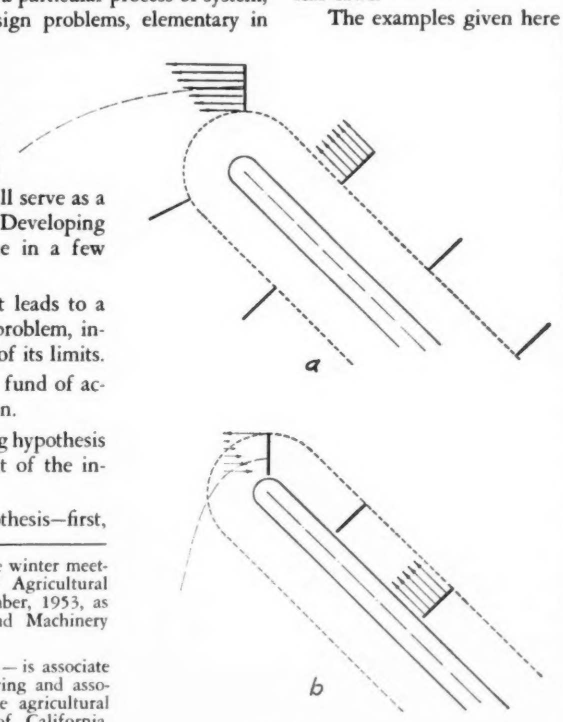


Fig. 1

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, as a contribution of the Power and Machinery Division.

The author — COBY LORENZEN — is associate professor of agricultural engineering and associate agricultural engineer in the agricultural experiment station, University of California, Davis.

change of direction, with an accompanying acceleration of the flights that imparts a propelling force to the onion, resulting in a trajectory as indicated by the dashed line. A modified design (Fig. 1-*b*) with the flights dropped below the conveyor line results in the same velocity during the straight portion of travel and the same acceleration along the curved path. Now, however, the velocity is rearward for the portions of the flights below the conveyor line. The flights now drop out from under the bulbs and allow them to drop into the sack.

A bean cleaner recently engineered by the department of agricultural engineering can be used as an example of a basic problem presented by the development of an hypothesis. The general problem concerned separating dirt and broken beans from the tailings of ordinary cleaners. Here again the physical properties of the product involved—namely, beans and clods—were studied and measured before an attempt at synthesis was made. Fig. 2 shows how the solution stemmed from the idea of utilizing the geometry and surface characteristics of the products. The sharp, saw-tooth surface allows all the various shapes—clods, bean pieces, and whole beans—to move *with* the teeth, but only the smooth, unbroken surface of the whole bean can be readily moved *against* the teeth. The complete process could then be broken down into elements of feeding, separation, conveying, etc., each with its particular design problem.

Not all problems presenting themselves are readily solved. One that grew out of work on the onion harvester was by-passed, on the basis that the machine could be made into a practicable unit without its solution. The machine was designed to lift onions by grasping their tops between two round rubber belts, set side by side and moving backward and upward as the supporting machine moved forward. The varying positions of plants along a row means that all onion tops will not be grasped at the same distance from the bulbs. Topping under this condition gives an undesirable variation in top length. Thus a gauging problem developed. The fact

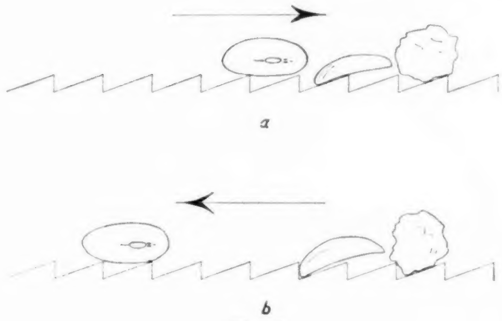


Fig. 2

that belts of round cross section were employed immediately suggested the idea of rotating the belts upward on their adjacent surfaces to pull the bulbs against a gauging device.

During the process of developing the machine, it was demonstrated that proper cultivation practices could produce a product of such uniformity that harvesting without a special gauging device was practicable. Thought was nevertheless given to this problem, since it was felt that the solution might have wide application. A possible arrangement could be as indicated in Fig. 3. A group of rollers, set as shown in Fig. 3-*a*, with their planes of rotation parallel to and intersecting along the axis of the belt, allows the belt to move with no rotation. With inclination of the roller planes at an angle to the belt axis, as shown in Fig. 3-*b*, longitudinal motion of the belt produces a couple with a lateral component, causing rotation. In an application involving two belts running together, energy would be stored in the belts by twisting them during the period of separation and then allowing them to rotate together in returning to their unstressed condition.

The example of the over-all development of the mechanical onion harvester can be taken to illustrate the operation of the organized research program aimed at design. In accordance with the steps outlined in the suggested procedure, the limits of the enterprise were definitely established. The

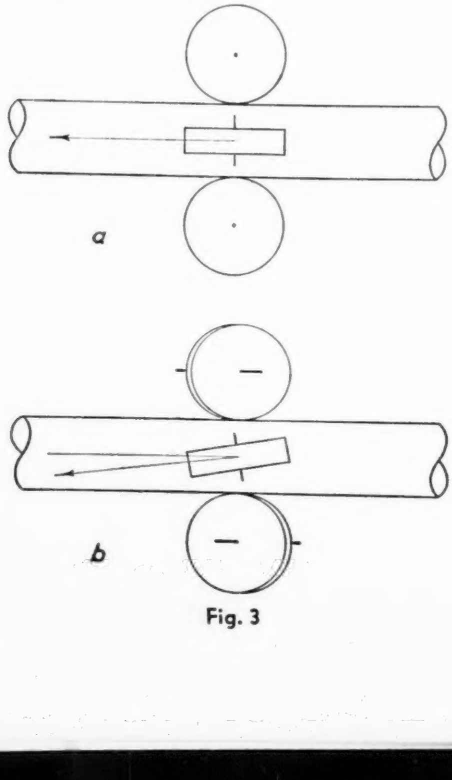


Fig. 3

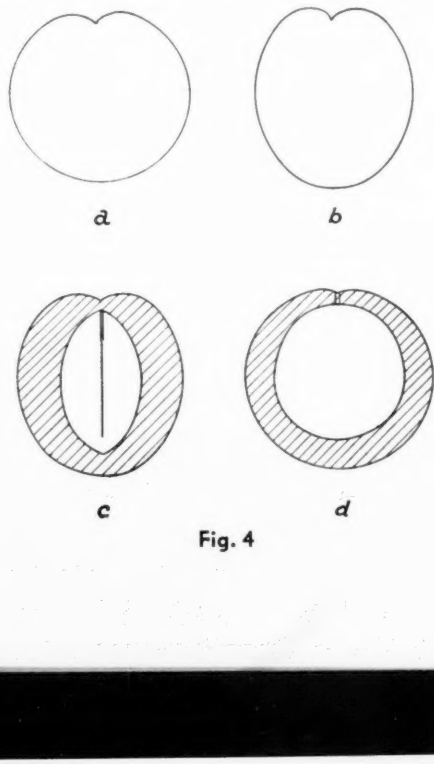


Fig. 4

general problem involved transfer of the product—free from roots, tops and dirt—from its growing environment to sacks or other convenient receptacles. Data was collected regarding the physical properties of the product and the behavior of the type of soil in which the product was grown. Development of a working hypothesis indicated a major separation problem, with onions and dirt in many cases being of approximately the same size and shape. Separation by reducing the clod size and screening would damage the tender onions. The program thus required a second analysis and synthesis. This process suggested lifting the onions by their tops, thereby eliminating the separation problem. Of course, it is seldom possible to resolve all difficulties with one design, but they may often be minimized.

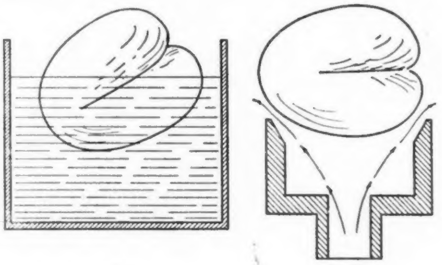


Fig. 5

Among projects in progress is the development of a machine capable of cutting apricots for sun drying. Here the general problem is to design a device, or series of devices, capable of accommodating apricots in bulk, singling the fruit so as to handle each separately, cutting it into two parts, removing the pit, and spreading the cut fruit on trays, ready for sulphuring and drying. At the same time the machine must be of such arrangement and capacity that it

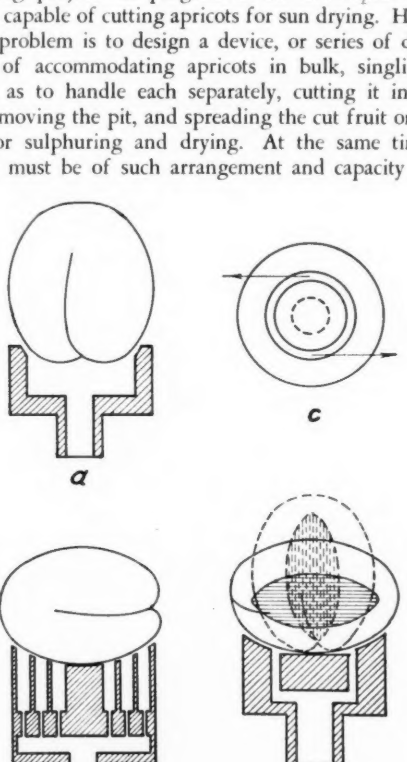


Fig. 6

may be owned and operated by the grower. This again is an example where several avenues of approach are open for developing a solution.

Adquate information about the product will help decide which of alternative hypothetical solutions will yield the most practicable machine. Apricots may be of three or more varieties, sizes ranging from those that require 18 or more to make a pound to those requiring 8 or less. Shapes may vary from practically spherical to a rather irregular prolate spheroid or ellipsoid (Fig. 4). The specific gravity of the fruit is very nearly unit. The pits of all varieties are round and relatively flat in shape and in the fresh fruit have a specific gravity greater than one. An additional disturbing factor is the firmness of the flesh, which varies greatly, not only among fruits but also within the different parts of a single apricot.

The arrangement of the pit in the fruit is such that it is most readily removed when the apricot is cut along the suture, a natural depression found near the stem end. It is therefore important to turn, or orient, the fruit so that each suture lies in approximately the same plane, and that this be the plane of the cutting knife or knives. In the problem described, the evidence indicated that it would be desirable to attempt to orient the fruit mechanically rather than by hand. Studies revealed that when floated statically in a fluid (Fig. 5-*a*), the plane of suture inclined at some 30 deg from the horizontal. This puts the sutures in a plane, but introduces a new problem, that of orienting the plane. The fact that static forces acting on the fruit suspended in a fluid partially satisfy the requirements, suggested that dynamic forces might have an effect on the orientation. Accordingly the apricot was placed in a stream of fluid (air), moving vertically upward with sufficient velocity to float it (Fig. 5-*b*). In almost all instances the suture oriented to a horizontal plane. Measurements were made to determine pressure, velocity, density, and shape relationships. These studies indicated that properties of the apricot other than mass distribution, density, etc., were the factors affecting orientation. The magnitude and direction of the fluid drag forces also have an influence. The important factors are that the fruit turns so that its greatest cross section is broadside to the stream axis, and that this cross section is normally parallel to the suture plane. And, in addition, the drag forces are acting along the surface of the apricot, so that small differences, due to variations in shape, etc., can produce turning efforts sufficient to rotate the fruit.

As another example of a simple design problem, when air was used as the fluid and a simple cell-type cup was employed, it was found that the apricot would not float if the fruit was positioned with the stem end down. Most of the available air flowed through the suture and the floating force was lost (Fig. 6-*a*). It was suggested that pressure could be produced evenly around the cup by metering the air through small orifices and into larger chambers. Even though several chambers were uncovered, the restrictions offered by the metering device would create sufficient pressure to lift the fruit and turn it to the desired position. A test of this arrangement performed as predicted (Fig. 6-*b*).

Another proposal for orienting the apricots was designed to make use of the mass distribution of the fruit. As noted before, the pit of the fresh fruit is round, relatively flat, and denser than the flesh. Rotation of the mass about a vertical axis should produce forces bringing the flat plane of the pit

into a horizontal position. A cup was constructed with an annular opening from which air flowed with a tangential component (Fig. 6-*c*). Fruit set on this cup quickly developed a rotation and oriented to a position with the suture in a horizontal plane (Fig. 6-*d*). Careful control of the air pressure at the cup was necessary in order to prevent the rotation rate from becoming excessive, which causes the apricot to part along the suture line, the upper half, and the pit to fly out. The lower half is held to the cup because of the high-velocity, low-pressure region just under the fruit surface at the annular opening.

Mechanical harvesting is being applied to many agricultural products. It is being attempted for many more, including tomatoes. Mention of such an operation usually brings to mind a complicated and elaborate device that would selectively pick and grade fruit at high speed. But actually a somewhat different picture develops when physical characteristics of the tomato and its vine are studied, the distribution of fruit on the vine and in the field are noted, and the present practices in harvesting with hand labor are recorded. Analysis reveals that, with the best hand picking, 10 to 15 percent of the total potential crop will be lost through damage to vines and fruit. Large vines, picked three or four times during the season, will make less efficient use of labor during the first and last pickings. Small vines on which all the fruit has a tendency to mature at the same time, can be spaced in the field so as to produce yields equal to those of large vines on wider spacing. The general solution, then, considers a relatively simple machine designed for once-through operation, digging and lifting the whole plant, separating the vine and fruit, discarding the vine and conveying the fruit to boxes for transport to the cannery.

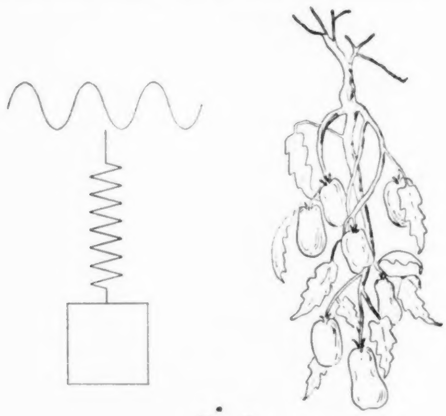


Fig. 7

Considering separation as only one element of a complete machine, the information was applied to devise possible methods of accomplishing this process. It was decided to attempt to orient the vine to a vertical position, with the root system at the top and fruit hanging at or near the lower end. The vine would then be shaken in a vertical plane to remove the fruit. The first procedure was accomplished by hairpinning the vine at its base over a horizontal rod, and then driving the rod through a reciprocating mechanism (Fig. 7).

The result of this arrangement was that the elasticity of the vine, together with the inertia of the mass of fruit, allowed the fruit to stand still as the vine moved up and down. Only about 10 percent of the tomatoes were removed. Also, at any but very low frequencies of the reciprocating bar, the top of the vine would fail to follow the amplitude of displacements and would remain in the air above the rod.

This is an example where the testing of a developed system yielded information that resulted in the modification of the original hypothesis. It was decided that the energy should not be transmitted to the vine but should be stored in the fruit. This could be accomplished by accelerating the whole mass of fruit and vine downward and then stopping the vine and allowing the fruit to pull itself off the vine. This is indicated diagrammatically in Fig. 8-*a*. A spring-loaded arm was pivoted at one end and arranged to rotate up and down about a horizontal position. A cam drove the arm downward against spring tension and at the end of a stroke the spring returned the arm to its original position against a stop.

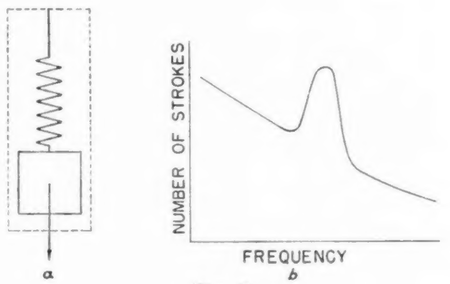


Fig. 8

Tests with this device were made with a large number of vines, whose weights and dimensions were recorded. They showed that this type of separating action would effectively strip the vines in a few strokes.

Other methods of separation would of course be possible as solutions to the problem. It was suggested that one could attach the vine to a device with enough energy to impart a very high acceleration to the vine and then depend upon the inertia of the fruit to hold it in one place. Tests on individual fruit indicated that it would be desirable to apply a steady pull to the fruit for separation. This might be done by holding the root system and swinging the vine about a vertical axis until the centrifugal force was sufficient to cause separation. An annular-shaped receiver rotating at the same speed would be necessary to catch the fruit and convey it to a central location.

Still another method of separation might be applied. The resistance to motion offered by a body is a function of its cross-sectional area, its shape, its velocity, and the density of the medium through which it is moving. Proper density and sufficient velocity might be attained to provide the force necessary for separation.

An interesting result of the tests made with the pivoted arm is indicated by the curve in Fig. 8-*b*, showing the relation between the number of cycles necessary to remove the fruit from the vine and the frequency of operation. These tests were made on a group of experimental vines being bred especially for mechanical harvesting. As the frequency increased, the number of strokes required to remove the fruit decreased. Continued increase in frequency develops a condition where the number of strokes required rises very rapidly and then drops off. This condition is

(Continued on page 318)

Parallel Rows and Parallel Terraces

F. O. Bartel

SOIL Conservation Service technicians, working with soil conservation districts in the southeastern coastal plain, have long been dissatisfied with the slow progress in getting contour cultivation adopted on the sloping lands. There are several reasons for this slowness. Farmers are accustomed to straight-row cultivation on their level lands and resent a change. The increased use of tractor-operated, multirow machinery has caused even more objection to the short rows that generally accompany contour cultivation and a large number of farmers just don't like crooked rows.

This wall of prejudice was first breached with the development of the "string method" of laying out tobacco rows by Soil Conservation Service technicians in the late thirties. Contour cultivation is a must for good tobacco farming on sloping land because it combines erosion control, moisture conservation, and row drainage. All of these are vital to good yields and to a longer life for the highest priced lands that these farmers possess — the acres suitable for growing tobacco.

Thousands of acres of cultivated Class IIe land in this section would benefit greatly from good contour cultivation. Soil Conservation Service and soil conservation district standards call for terracing or contour strip cropping. Either one would result in contour cultivation, also specified, but neither has been widely accepted. Progress has been slow.

It was to do something about this situation that the author started a number of field trials of parallel rows on fields, without terraces, in the fall of 1952. They were located in Jones and Craven Counties, North Carolina. Reports and field examination of these were encouraging, so a number of additional trials were staked off in South Carolina and Virginia early in 1953.

Review of the "String Method" of Tobacco Row Layout

The procedure for laying off the parallel rows and terraces described in this paper is based on the elements of the "string method" with some variations. A thorough familiarity with this method is essential. The string method is described in USDA Miscellaneous Publication No. 656, "Conservation Practices for Tobacco Lands of the Flue-Cured and Maryland Belts." For the benefit of those not familiar with the string method and to accentuate points found particularly adapted to the parallel-row method, the following brief resume is given.

1 The "string method" was developed to provide a positive means of obtaining drainage for all the rows in the area between two terraces. Continuous row drainage serves two main purposes: it prevents "flopping" or drowning of tobacco and it prevents row-grade reversal and consequent row breakage. It is the only method known by which every row will be assured of drainage with the minimum fall possible, when all the rows are parallel. This statement is strictly true only when the area between terraces is a smoothly warped surface. Any bad washes, gullies, or other irregularities may prevent proper functioning of the system, or require modifications.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author—F. O. BARTEL—is engineering specialist, Soil Conservation Service, U.S. Department of Agriculture, and presently on detail to the U.S. Department of the Navy for making a reconnaissance survey of erosion conditions of all Navy lands in the 5th Naval District.

2 A guide row is laid out between the terraces, using a string or cord. All rows in the interterrace area parallel this guide row, and all will have continuous grade and drainage.

3 The basic principle of the method is that, when two terraces drain in the same direction from a flatter to a steeper slope (i.e., from a wider to a narrower interval), the rows must parallel the upper terrace. Conversely, when they drain from a steeper to a flatter slope (i.e., from a narrow to a wider interval), they must parallel the lower terrace (Fig. 1).

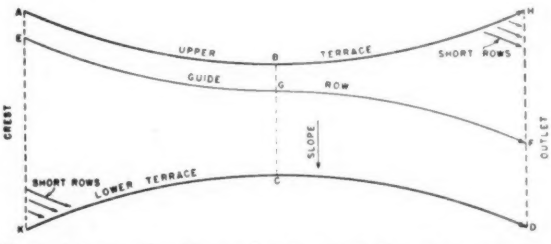


Fig. 1 Location of guide row by string method to give continuous row drainage. Guide row *EF* is parallel to terrace *AB* as long as the slope is increasing (i.e., as long as the terrace interval is narrowing). *BC* is the narrowest point in the terraces interval, i.e., the steepest part of the field. From *G* the guide row parallels *CD*. All rows in the terrace interval will parallel *EF*. All short rows will be in the corners near *H* and *K*

4 Not many terrace intervals widen or narrow all the way from the crest to the outlet. In some places the interval will narrow when the slope steepens. In others, where the slope lessens, the interval will become wider. (In places the two terraces may even be parallel.) In such cases, the guide row will follow first one and then the other terrace (Fig. 1). In most cases these changes in slope and width cannot be detected by the eye but must be found with the string. This is one important reason for using the string in laying off the guide row.

5 Three men are the usual crew for staking off the guide row. One man, with the ball of string, walks in the upper terrace channel. Another with the loose end of the string walks in the lower terrace channel. The third holds on to one place on the string and walks out and marks the guide row. They always start at the crest and work toward the outlet. The duties of each of the three men are as follows:

Upper Man. The upper man always has the ball of string. He either holds tight or gives out string. He *never* takes up string. When the upper terrace is the guide, he holds tight. When the lower terrace is the guide, he lets out string gradually, as needed, but keeps the string tight. He must notice the moment when the string loosens. This shows that the terrace interval is narrowing and that the lower terrace is no longer the guide. He then calls out

"follow me," calls the middle man back, if they have gone past the point where the upper terrace should have been used as a guide, and starts over from there.

The upper man must keep the middle man perpendicular to the upper terrace when his terrace is used as a guide. He must keep himself lined up with the middle and lower man when the lower terrace is the guide.

Middle Man. The middle man starts about a row or so below the crest of the upper terrace, lines himself up perpendicular to it, tightens his hold on the string, and starts walking toward the outlet. Both upper and lower man keep the string tight. This is a trial start. If the lower man finds that he has to take up string, all is well as the upper terrace is the proper guide. However, if the lower man finds himself being pulled up into the terrace interval, it signifies that the lower terrace should be the guide. He calls out "Follow me," and they must go back and start over again.

The middle man cannot tell which terrace to follow. He follows directions from the upper and lower men, keeps himself perpendicular to the terrace currently used as a guide, holds on to his spot on the string, and keeps himself alert to call attention to any mistakes made by the others. He also sets stakes for the guide row at rather frequent intervals, particularly around curves.

An experienced middle man will also watch out for washes or knolls as he walks along. If either of these are crossed, it will be necessary to throw in a little extra fall to carry the row water out of or around such places. In this case, he breaks the rule of always holding on to one point of the string by moving a distance equal to one or more row intervals down the string. He *never* moves up the string.

Lower Man. The lower man keeps in line with the middle man and upper man when the latter is the guide and keeps the string taut, taking it in as necessary. He *never* gives out string. He always holds tight so as to tell the exact moment his terrace should be used as the guide. He can tell this when he is pulled up into the terrace interval. He may not be immediately aware that this is happening, but when he does he calls out "Follow me." All three then go back to the point where this started and reset any stakes that have been set improperly. He watches that he stays in his terrace channel and helps keep the middle man at right angles when the lower terrace is being followed as a guide. At other times he walks faster or slower as necessary to keep in line with the middle and upper men.

Further adjustments will often be needed in the guide row, especially on rough land. For example, if the two terraces parallel each other the guide-row grade will be the same as that of the terraces. The grade of this part of the guide row may then be less than in the section above. Too much flattening may cause deposition and row breakage. Consequently more slope should be thrown into this part of the guide row.

Parallel Rows and Parallel Terraces

On any soils in which the infiltration rate is less than that of the rainfall, water will accumulate and the rows will carry runoff. Rows will break at low points where they have a reversal in grade. This will cause the breaking of rows below and the deposition of soil in the terrace channel. This may, and frequently does, cause overtopping and breaking of the terrace ridge. Consequently the individual row is of the utmost importance in contour cultivation, and the water-disposal system should be developed from the standpoint of first getting a workable row system and then developing the terrace system. *The row comes first.* This is especially logical when a parallel system of terraces is desired. Each row must have continuous grade from the crest to the outlet. The grade will not be uniform, however.

How to Lay Off a System of Parallel Rows

The method of laying off such a system on a field scale is as follows:

1 Stake a simulated terrace channel as far up the field slope as possible. This should usually be within about 50 feet of the upper edge of the field or ridge.

2 Stake off another simulated terrace channel as far down the field as possible without going over onto a decided slope change. Pay no attention to the distance or interval between these lines.

3 Use the string method in laying off a guide line.

4 Take up the stakes set for each of the simulated terraces. These lines are no longer needed.

5 Take the string and with level and rod check a long row as far up the slope as possible. Take readings every 50 ft. If there is any backfall, move the next stake *in the guide row* (below the point where backfall starts) downhill until some row grade results. *If one stake is moved down slope, all the rest on to the outlet must be moved the same distance.* Do this, and continue checking to see if any further backfall is found in this upper long row. Make corrections in the guide row if needed. Record the readings on the long row to determine the maximum and average grades and length of row.

6 With the string, level, and rod, take readings at 50-ft intervals on a long row far down the slope. If there is any backfall, make corrections in the guide-row alignments as under 5 above. Usually only one (either the upper or lower but not both) of the test rows may reveal backfall. Record readings to determine the length of the row and the maximum and average grades.

7 Mark the guide row well, usually by backfurrowing upon it so it won't be lost.

8 Explain to the farmer just what has been done and why, and where his short rows will be. Tell him also that all this work will be wasted if he loses his guide row.

9 Explain how there may still be a possibility of row grade reversal somewhere in the field because of local variations in topography, in spite of our care in laying off the system. If a row should have broken because of row-grade reversal, this may be corrected at the end of the season by dropping down a row or two in the next 30 to 50 ft toward the outlet below the break and changing all the rows in the field accordingly. But if the breakage can be corrected some other way, as by smoothing or land leveling, this may be better.

10 At the end of a season when no rows have broken, plow up at least one of the long rows — preferably about half a terrace interval down the slope from the ridge or at a key position — as a permanent guide. This may be developed into a terrace.

11 As a further guard against erosion during those periods in the crop rotation when there are no deeply ridged rows, a system of oversized rows may be built to break up the length of the slope. As these will always have considerably more grade than regular terraces, they should be located at closer intervals than is customary for terraces. This will reduce the amount of water collected and also the velocity and cutting action.

The oversized rows may be converted into channel-type terraces. It is thought that they should be about one-half or two-thirds the spacing of regular terraces. The same principle as in locating key terraces should be used as a guide in locating these terraces.

12 Suitable outlets for the rows, prepared and vegetated in advance, must be provided to care for the water draining from the rows and concentrated at the ends of the terraces.

13 Under 2, a warning was given not to go onto a part of the field having a decided change in slope. If such a slope change occurs in the field, or the slope is so long that row grades become excessive, a diversion, terrace, or road may be used to divide the field into sections. Each of these will have its own parallel-row and terrace pattern.

Observations on the Parallel-Row Method

Conclusions from the experience with this method to date are that it will work in a deep soil, with well-ridged crops, on moderate slopes and uniform topography. In general, it is ideally adapted to smooth Class IIe soils in the southeastern coastal plain.

So far the majority of the fields in which the system has been tried are on slopes of about 5 percent and under. Slope lengths have been limited to approximately 700 ft or less, and the row length to 700 ft or less from crest to outlet.

Talking to farmers who have tried the system, many who always objected to terraces because of the crooked rows, no longer object to crooked rows. The short rows within the terrace interval are what they really objected to. With the new system, all short rows are thrown into the corners of the field. There are none in the interior, except where more than one guide row is needed. A few farmers have sown these odd corners to a cover crop so as to eliminate a number of the shortest rows.

One of the things they like most is that the guide row has much less curvature and much better alignment than the terraces. More of the water is delivered to outlets farther down the slope than with terraces.

In a considerable number of cases, the final location of the guide row was parallel to the upper ridge in the field. In such cases it was often possible to carry the row system over the ridge and down the opposite slope, even though the system had been worked out for the slope on only one side of the ridge. Trial rows parallel to the guide rows were so frequently on a satisfactory grade that it has become standard practice to check such rows on the slope over the ridge.

In several cases it was found satisfactory to use the upper ridge line instead of the usual simulated upper terrace as a guide for the string. The grade of the ridge in these cases was somewhat greater than that of the lower simulated terrace channel, which was laid off as usual.

The system appeals to our technicians even though it takes more walking and more time than is usual in staking out a terrace system. On many fields no terraces will be needed and where needed the construction is postponed, usually to a more convenient time. The often neglected and difficult job of working out a satisfactory row system between terraces is eliminated. The result is a practical contour system on the land, one that pleases the farmer and one that he will maintain.

Row Grades

The maximum allowable grades will depend upon the infiltration characteristics of the soil, the area drained (i.e., row length and width) and the condition of the crop and of the soil surface. It is evident that considerably more grade may be given to a single row than to a terrace. Terraces in the tobacco areas are often given a grade of 0.4 or 0.5 ft per 100. Rows in tobacco fields do not usually drain more than 300 to 500 ft in one direction, and experience shows that grades up to 2 or 2½ percent are often allowable, especially for short rows.

The row grade can be determined mathematically if the changes in slope and topography are uniform. However, irregularities in field conditions make it impractical to design a parallel-row system mathematically. The design should be developed in the field by laying off a guide row with the string, and making adjustments as needed and as described earlier in this paper.

There are four idealized conditions as stated in the following paragraphs. A study and understanding of the formulas derived will be very helpful in using the system.

Case I (Fig. 2)—Simulated terraces drain from a flatter to a steeper slope and rows are *down slope* from the guide (upper) terrace.

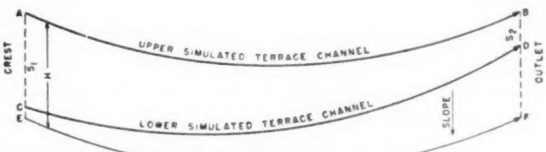


Fig. 2

Given g = grade of simulated terraces AB and CD, feet per 100

S_1 = slope of field at crest (flatter slope), feet per 100

S_2 = slope of field at outlet (steeper slope), feet per 100

H = horizontal distance of row down slope from guide (upper) terrace, feet

L = row and terrace length (in 100 ft stations).

Find G = grade of row EF (feet per 100)

Let V = vertical interval between A and E.

Then $V = HS_1/100$ and $H = AE = BF$

Assume elevation of point $A = 100.0$

Then elevation of point $E = 100 - (HS_1/100)$

Then elevation of point $B = 100 - gL$

Then elevation of point F = elevation of point $B - (HS_2/100)$

$= 100 - gL - (HS_2/100)$

Difference in elevation between E and $F = 100 - (HS_1/100) - 100 + gL + (HS_2/100) = gL + H\,(S_2 - S_1)/100$

G = grade of row $EF = g + H\,(S_2 - S_1)/100L$

In this case all values of $S_2 - S_1$ and of G are positive, and the greater the distance H, the greater will be the grade of the row.

Example: Assume $g = 0.4$ ft per 100

$S_1 = 2$ percent

$S_2 = 4$ percent

$H = 200$ ft

$L = 5$ stations of 100 ft

Then $G = 0.4 + \frac{200\ (4-2)}{100 \times 5} = 0.4 + 0.8 = 1.2$ percent

Note that G increases directly with H, and with the difference in field slope, but inversely with L.

Case II (Fig. 3). Simulated terraces drain from flatter to steeper slope (as in Case I), but rows are *upslope* from the guide (upper) terrace.

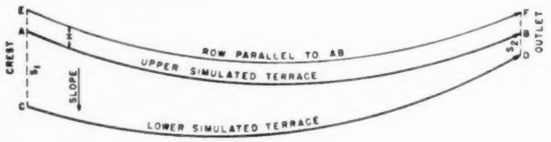


Fig. 3

In this case, G (the grade of row EF) $= g + H\,[(S_1 - S_2)/100L]$. As H increases, the row grade lessens until it becomes zero, and then turns negative, showing row grade reversal. Let H_0 = horizontal distance from guide terrace to point where row grade becomes zero. Then $H_0 = 100gL/(S_2 - S_1)$. If rows are carried beyond this point, an outlet at the left must be provided to take care of the row drainage. Evidently this would be impractical.

Example: Using same factors as in the preceding example,

$H_0 = 100 \times 0.4 \times 5/(4-2) = 100$ ft

If $H = 200$ ft, $G = 0.4 + 200\ (2-4)/(100 \times 5) = 0.4 - 0.8 = -0.4$ percent

Case III (Fig. 4). Simulated terraces drain from steeper to flatter slopes, but rows are down slope from the guide (lower) terrace (as in Case I).

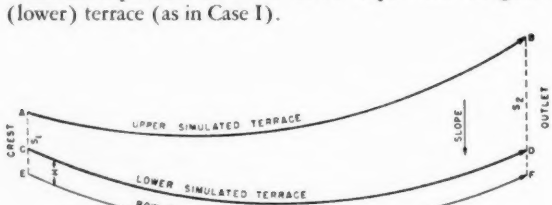


Fig. 4

In this case, G (the grade of row EF) $= g + H\,(S_2 - S_1)/100\,L$. As in Case II, this leads to negative values of G as H increases beyond the point where the grade becomes zero, or H_0. $H_0 = 100gL/(S_1 - S_2)$ and if the same values are inserted as in the previous example, the distance of the row having zero slope will likewise by 100 ft from the guide terrace. An outlet must be provided at the left for any parallel rows beyond this point. In the case of crops which can stand zero or near zero row grades, the rows can be extended to H_0 and beyond, provided an outlet is supplied. The rows can then be run down slope until the maximum permissible grade is reached.

Case IV (Fig. 5). Simulated terraces drain from the steeper to flatter slope (as in Case III) and rows are *upslope* from the guide (lower) terrace (as in Case II).

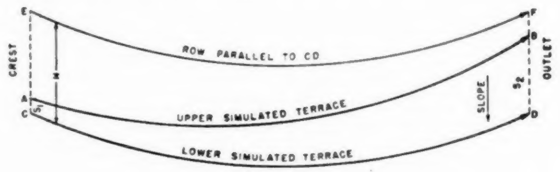


Fig. 5

In this case, G (grade of row EF) $= g + H\,(S_1 - S_2)/100\,L$. $S_1 - S_2$ and G are positive in all cases.

In general, G increases directly with H and with the difference in slopes, but inversely with L, the distance in which the slope change takes place.

Shape of Field

Case I. Care should be taken not to make H too large. In Case I, $H = 100\,L\,(G-g)/(S_2 - S_1)$ which is always positive. Until experience shows otherwise, it will be best to limit the value of G to 2.5 percent; less on highly erodible soils. A commonly used value of g is 0.4. Substituting this value $H = 210\,L/(S_2 - S_1)$ for Case I. The following table shows values for this equation:

TABLE 1. Values for H for $G = 2.5$, $g = 0.4$

$S_2 - S_1$	Values of L: $L=1$	$L=3$	$L=5$
1	210	630	1,050
2	105	315	525
3	70	210	350
4	53	158	262
5	42	126	210

These figures indicate the decided effect of increasing the slope length and of decreasing the length of row in cutting down the number of rows which may be run parallel to and down slope from the guide terrace. The best results will come from the wider fields with shorter slopes, slope difference remaining constant.

Case II. In this case, $H_0 = 100\,gL/(S_2 - S_1)$ which is the point where row grades become zero and beyond which they will reverse. Table 2 gives values of H_0 when $G = 2.5$ and $g = 0.4$. Then $H_0 = 40\,L/(S_2 - S_1)$.

TABLE 2. Values of H_0 for $G = 2.5$, $g = 0.4$

$S_2 - S_1$	Values of L: $L=1$	$L=3$	$L=5$
1	40	120	200
2	20	60	100
3	13	40	67
4	10	30	50
5	8	24	40

By combining Tables 1 and 2, we can illustrate the maximum total distances between H_0 and the row down slope having the maximum permissible grade (Table 3).

TABLE 3. Combined Distances Up and Down Slope from Guide Terrace, Cases I and II

$G = 2.5$ $g = 0.4$

$S_1 - S_2$	Values of L: $L=1$	$L=3$	$L=5$
1	250	750	1,250
2	125	375	625
3	83	250	417
4	63	188	312
5	50	150	250

(Continued on page 318)

Contemporary British and European Tractors

Wayne H. Worthington
Fellow ASAE

(Continued from the March and April issues)

Italy, with an arable area of 36,000,000 acres, was served in 1951 with a total of 12 manufacturers of wheel tractors producing a total of 22 models. These manufacturers fall into two main categories, viz., the government owned IRI Group, which includes Ansaldo, Motomeccanica, and OTO; and the independent group, which includes all others.

The largest producers in 1949 and 1950 were Fiat, who produced 974 in 1949 and 1,287 in 1950; and Landini, who produced 450 in 1949 and 506 tractors in 1950. A small number of track-type tractors are manufactured in sizes from 25 to 130 hp. As of January 1, 1951, there was one tractor for each 573 acres of arable load, but as a result of increased domestic production and heavy imports, largely from Western Germany, tractor density has since been greatly increased.

The FIAT Automobile Works, organized in 1899 as the Fabrica-Italiana Automobile Torino with 50 workmen, has grown until today it comprises a total of 15 production plants spread over 6000 acres of land and employing a total of 65,000 people. Many of its latest and best machine tools are of American manufacture provided by Marshall Plan funds. Other than automobiles, trucks, and wheel and track-type tractors, it produces such varied items as household refrigerators, complete petroleum refinery installations, steam and diesel electric generating plants, aircraft engines, marine propulsion and auxiliary engines, locomotives, and railway cars. In addition it provides its raw and semifinished materials from its own blast furnaces, steel mills, foundries, and forge shops.

The author – WAYNE H. WORTHINGTON – is director of engineering research, John Deere Waterloo Tractor Works of Deere Manufacturing Co.

At present two models of diesel-powered wheel tractors are in production, the smaller of which is shown in Fig. 34. Brief specifications are as follows:

Model	25R	35/40R	
Maximum horsepower (advertised)			
Engine	—	37.0	
Belt	24.0	35.0	
Number of cylinders	4	4	
Bore and stroke, in	3.22 x 3.54	3.94 x 4.72	
Rated engine speed, rpm	2000	1500	
Piston speed, fpm	1180	1180	
Compression ratio	20:1	16.1	
Operating weight, lb	3505	5460	
Weight per belt horsepower, lb	146	156	
Wheelbase, in	58⅜ low clearance 60¾ high clearance 70¾ general purpose		
Tires			
Front	5.50 x 16	6.00 x 19	
Rear	10-28	11-36 & 12-28	
Transmission gearing	Spur Sliding gear	Helical Constant mesh	
Travel speeds, mph			
Forward		*12-28*	*11-36*
First	2.3	1.30	1.48
Second	3.2	2.11	2.36
Third	4.4	2.98	3.42
Fourth	9.3	3.60	4.10
Fifth	—	5.78	6.57
Sixth	—	8.20	9.32
Reverse			
First	2.4	1.74	1.93
Second	—	4.72	5.41
Tread range, in			
Front wheel	50.8 to 64.7	53.5 to 72.5	
Rear wheels	48.8 to 67.2	47.2 to 78.8	
Power shaft			
Size	—	1⅜, 6 spline	
Speed, rpm	—	550	

Twenty-four-volt electric starting is regularly provided for both models. Three-point implement attaching linkage, with hydraulic lift, is available as optional equipment. This

Fig. 34 Fiat Model 25R tractor

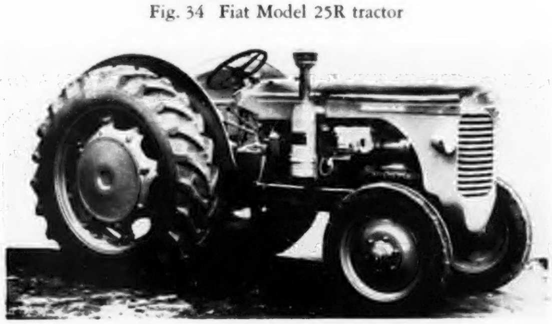


Fig. 35 Motomeccanica farm tractor

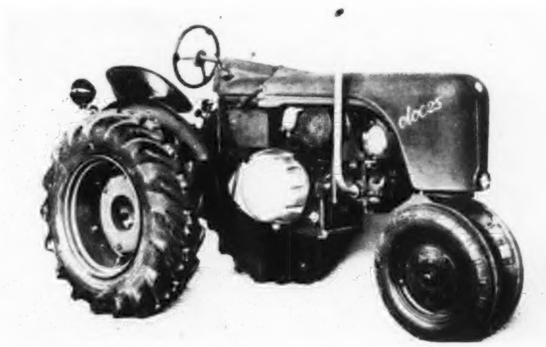


Fig. 36 OTO Model 25 tractor

system does not include any automatic means of controlling draft or working depth. The inconsistencies in available travel speeds indicates that little attention was given toward providing speeds for both tractors best suited for general field conditions.

Optionally available for the Model 25 series are spark ignition engines suited for operation on either gasoline or distillate. These engines have a bore and stroke of 3.35 x 3.94 in, respectively, and deliver maximum power at 1750 rpm.

MOTOMECCANICA, of Milan, manufactures wheel tractors in three models, two of which are equipped with diesel four-cycle engines. The smaller diesel tractor is equipped with the English-built Perkins Model P3TA diesel engine. The largest of these is shown in Fig. 35. Brief specifications are as follows:

Model	MR75	RP3	R108
Fuel	Gas-dist	Diesel	Diesel
Rated horsepower	20	24	45/50
No. of cylinders	4	3	4
Bore and stroke, in	2.95 x 4.01	3.5 x 5	4.25 x 4.72
Engine speed, rpm	1800	2000	1600
Travel speeds, mph			
Forward			
First	2.21	2.33	2.34
Second	3.30	3.48	3.23
Third	5.15	5.41	4.73
Fourth	10.88	11.42	6.69
Fifth	—	—	9.20
Sixth	—	—	13.38
Reverse			
First	2.21	2.33	1.82
Second	—	—	5.16
Wheel treads, in			
Front—min	48	48	52.8
max	55.1	55.1	60.6
Rear—min.	48	48	56.6
max	55.1	55.1	66.2
Tires			
Front	4.00 x 19	4.00 x 19	6.00 x 20
Rear	10-28	10-28	12-38
Weight, lb	2640	2720	5940

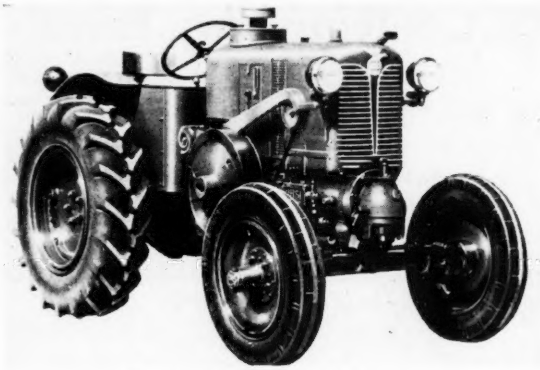


Fig. 37 Orsi Model Artiglio tractor

A 24-v starting motor is used on the largest tractor, with 12-v motors on the two smaller models. A rear power shaft and a hydraulic lift, without automatic draft and depth control, are optionally available. The belt pulley is at the rear and no three-point implement attaching linkage is available.

Incomplete information is available from three Italian manufacturers of wheel tractors equipped with single-cylinder, two-cycle engines. Of these, the air-cooled OTO is the full diesel type with a compression ratio of 18:1, while the other two are of the low-compression hot-bulb type, are as follows:

Tractor Name	Manufacturer
OTO	Societa Meccanica della Melara, La Spezia
Orsi	Pietro Orsi & Figlio, Tortona
Landini	Giovanni Landini & Figlio, Sede Sociale, Fabrica Reggio, Emilia

These tractors are shown in Figs. 36, 37, and 38, respectively. Brief specifications are as follows:

Name	OTO	ORSI		LANDINI	
Model	C25	Artiglio	Argo	L 25	L 45
Maximum belt horsepower, rated	20	35	55	25	50
Bore and stroke, cu in	5.12 x 5.51	7.88 x 9.06	9.25 x 10.23	—	—
Displacement, cu in	113.2	442	687	262.5	580
Engine speed, rpm	1400	750	650	880	740
Starter	12-v electric inertia	—	—	—	—
Scavenging	Crankcase	Crankcase	—	—	--
Travel speeds, mph					
Forward					
First	2.02	1.96	1.86	2.36	2.24
Second	2.64	3.24	2.68	2.98	2.80
Third	3.57	5.03	3.35	4.23	3.42
Fourth	4.66	7.78	4.53	9.34	9.34
Fifth	6.97	—	5.53	—	—
Sixth	9.14	—	8.16	—	—
Reverse					
First	1.86	1.77	1.83	2.18	2.28
Second	2.43	—	4.49	—	—
Power shaft					
Size, in	—	1⅜, 6 spline	—	—	—
Speed, rpm	560	560	—	—	—
Tires					
Front	5.50 x 16	6.00 x 20	16.50 x 20	6.00 x 16	6.50 x 20
Rear	10-28 & 11-24	11.25 x 24	13-26 & 12.75 x 28	10-25	12-38
Operating weight, lb	3300	3740	7480	3520	6820

Fig. 38 Landini Model L25 tractor

Since there are no means for attaching front-mounted implements to the OTO tricycle tractor, the objective of this design is obscure. Although Italian tractor manufacturers evidenced every willingness to cooperate in supplying requested data, that which was made available was so limited it was impossible to analyze the design objectives or evaluate performance. In any event Italian tractors as now manufactured lack much of the versatility which is so necessary to adequately power today's varied power-farming implements. At this time, an official tractor testing institute is being set up in Italy, and it is expected that the test procedures and methods of reporting information will generally follow that of the Nebraska Testing Board.

The single Italian effort to provide a general-purpose tractor for the small farmer is the recently announced CELENE tractor built by the Off. Mec. Ing. A. Feraboli of Cremona. This small four-wheel, open-frame tractor is of the "implement-carrier" type. It is powered with a rear-mounted, single-cylinder, air-cooled gasoline or diesel engine developing a maximum of 11 bhp. The frame consists of rear channel side members bolted to forward tubular members. These latter follow somewhat the design of the American-built Allis-Chalmers Model G tractor. The wheelbase may be lengthened or shortened as required, and the wheel tread is adjustable from 50 to 80 in. Implements such as grain drills, wagon boxes, mower cutter bars, and cultivators are all carried amidship. Four forward speeds permit travelling from 1 to 10 mph. Unfortunately its manufacturer has not replied to requests for information regarding its operation or the extent of its usefulness.

Next to Switzerland, Sweden until 1953, had the highest concentration of tractors on the continent of Europe. However, the extent of mechanization is greater than might be indicated by statistics alone, since Swedish farms are generally large and their agriculture is particularly suited to mechanized operations. Sweden is the only country in Europe that is self-supporting in agricultural production, although only 10 percent of her area is arable and not more than 25 percent of the population is engaged in agriculture. As of June 1, 1953, tractors in Sweden total 90,000 and there are 11,000 combines in use. Sweden's one tractor builder, the firm of AB Bolinder-Munktell, was created several years ago by the merger of Sweden's two long-established diesel and semidiesel engine builders—Bolinder of Stockholm and Munktell of Eskilstuna. More recently this merged operation was taken into the Volvo group, which is the sole automotive producer — cars, trucks, and tractors — in Sweden.

Both predecessor companies have pioneered in the development of "hot-head" solid-injection compression-ignition two-cycle engines, built prior to the invention of the diesel engine. Munktell was a well-established manufacturer of threshers of the conventional European raspbar cylinder type and other heavy farm implements. As a result of the dependable performance and long life of their product, they had expanded into world markets. Their experience with wheel tractors dates from 1913 when the tractor shown in Fig. 39 was built. Odd as it appears today, it did not differ significantly from its American contemporaries, except that it was capable of burning almost any dirt-free liquid fuel that could be poured into it, including crude oil. Up until a year ago, all of the tractors built by Bolinder-Munktell were of the two-cycle hot-bulb type. The specific variable-load fuel consumption of the Bolinder-Munktell tractor officially reported from Ultuna is shown in Fig. 40.

In 1952 production was started on two entirely new tractors powered respectively with three and four-cylinder diesel engines. A single basic cylinder is used with a bore of 4⅛ in, a stroke of 5⅛ in, and a compression ratio of 16.5 to 1. Governed speed is 1500 to 1800 rpm. The hemispherical combustion chamber is formed in the head, and great attention is paid to obtaining the high swirl necessary for clean combustion and high air utilization. These tractors

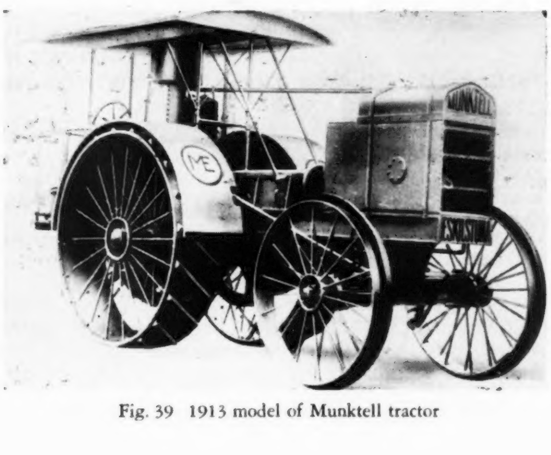


Fig. 39 1913 model of Munktell tractor

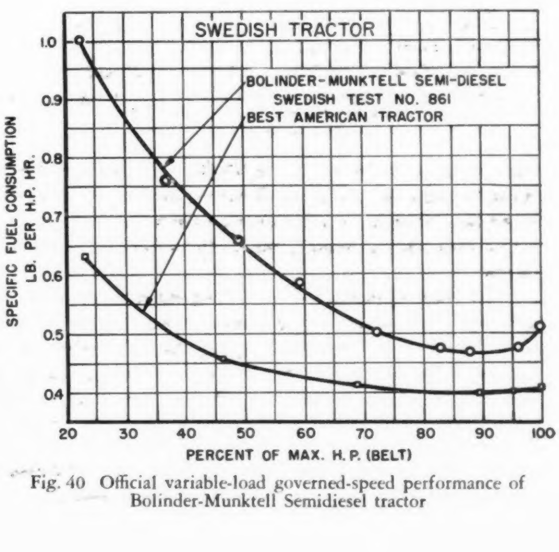


Fig. 40 Official variable-load governed-speed performance of Bolinder-Munktell Semidiesel tractor

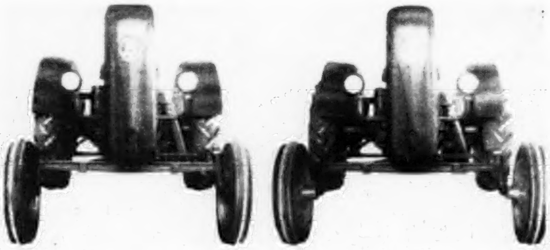


Fig. 41 Front view of Bolinder-Munktell Model BM-10 tractor

are sold under the names Bolinder-Munktell and Volvo, differing only in color scheme.

Because of their long experience in building farm machinery, the general construction of their tractors reflects the engineering objectives of best American contemporary standard tread designs: i.e., ruggedness and long life, convenience, good weight distribution, operator comfort, vision, etc. A front view of their smallest tractor is shown in Fig. 41 and the excellent visibility from the driver's seat in Fig. 42. Heavy swinging drawbar and three-point implement attachment linkage are both provided. Row widths in Sweden are such that drop axles can be used to provide adequate crop clearance under the rear-axle housings, and adjustable front and rear-wheel treads are provided. Unfortunately, full specifications have not been made available.

In no European country is the national economy so dependent upon the production of its land as in Western Germany. As the largest segment of the German machine-building industry, the manufacture of farm machinery serves the dual purpose of mechanizing agriculture for increased food production and bringing in foreign exchange necessary for the purchase of foodstuffs and raw materials abroad. The number and sizes of West German farms and the number of tractors on farms are shown in Table 6. Of particular note is the fact that 80 percent of all farms, totalling 39.4 percent of all farm land, are smaller than 25 acres. Animal power is scarce with only 1,360,000 horses for a total of 1,908,237 farms.

The problem of quickly converting the farms of Western Germany from animal to mechanical power is as complex as it is difficult. It involves changing the deep-seated work habits and the traditional way of life of a timeless peasantry. Not only horses, but largely the labor of men, women, children, and cows now tilling the fields of the so-called "family" farms, must be replaced. New implements are required, which involves distressing changes from long-established practices of tilling, planting, cultivating, and harvesting.

TABLE 6. WEST GERMAN REPUBLIC NUMBER AND SIZES OF FARMS AND NUMBER OF FARM TRACTORS — 1952*

Size of farms	Acreage	Percent of total acreage	No. of farms	Percent of total farms	Total tractors on farms	Percent of total tractors	Tractor density†
Less than 5 acres	1,649,176	4.9	1,125,676	59.0	13,508	5.8	1.2
5 to 12.5 acres	4,509,990	13.4					
12.5 to 25.0 acres	7,101,554	21.1	400,308	21.0	35,627	15.3	8.9
25 to 50 acres	8,818,043	26.2	254,466	13.3	83,719	35.8	32.9
50 to 125 acres	8,111,253	24.1	112,086	5.9	75,994	32.6	67.8
125 to 250 acres	2,053,056	6.7	15,701	0.8	24,399	10.5	155.4
250 acres and over	1,413,581	4.2					
Total	33,656,643	100.0	1,908,237	100.0	233,247	100.0	12.2 avg.

* From data supplied by the Institute for Tractor Research, Braunschweig-Volkenrode, and the Association of Tractor and Farm Machinery Manufacturers, Munich.

†Tractor density = number of tractors per 100 farms

Fig. 42 View from seat showing excellent visibility of Bolinder-Munktell Model BM-10 tractor

In contrast with the unprecedented recovery of West German industry made possible through the help of the Marshall Plan and the business boom accompanying the armies of occupation, little progress has been made toward increasing the production of the family farms of Western Germany or improving the lot of these small farmers. This is because little of the power-farming equipment received from abroad has been suited to the needs of the small farms. Much of the agricultural research sponsored by the government is primarily directed toward improving the production of small farms by promoting complete mechanization.

Tractor production in the German Republic has increased from approximately 7,600 units in 1948 (1)* to 87,305 in 1952 (5). A breakdown of these into sizes and domestic and export deliveries is shown in Table 7.

The domestic need for small tractors is clearly emphasized by the relatively small percentage of such tractors sold abroad. A further evidence of the attention being given to the mechanization of "family" farms is the development of small tractors known as "implement carriers." These are discussed in detail later.

One factor greatly affecting the design of German tractor engines is the quality of the fuel available. Since the end of World War II, liquid fuels have been variable in quality and with a sulfur content at times in excess of 2 percent. Since no petroleum is produced in Western Germany, great impetus has been given to

TABLE 7. 1952 TRACTOR PRODUCTION WEST GERMAN REPUBLIC

Engine power	Domestic sales	Export shipments	Total	Percent exported
12 hp and less	10,265	335	10,600	3.2
13 to 18 hp	22,325	2,994	25,319	11.8
18 to 25 hp	19,265	3,719	22,984	16.2
25 to 35 hp	11,294	8,975	20,269	44.4
Over 35 hp	1,273	6,860	8,133	84.3
Total	64,422	22,883	87,305	26.2

*Numbers in parentheses refer to the appended references.

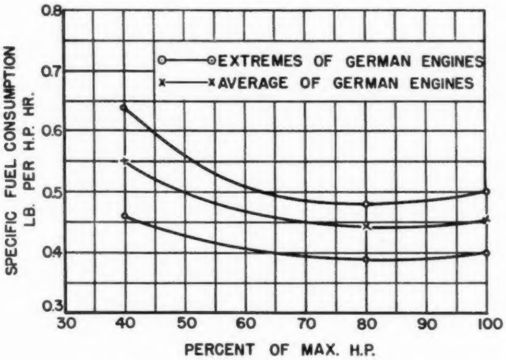


Fig. 43 German diesel tractor engines

synthesizing motor fuel from the nation's extensive supplies of peat and lignite. Although these fuels are at present not generally available, processes are already developed which could be used should conditions require it. Under these circumstances, it has been necessary to go to extreme lengths to develop ways of inhibiting cylinder and ring wear. This has resulted in the successful development of a number of air-cooled engines, which operate with cylinder-wall temperatures above the dew point of the sulfur compounds present and minimize cylinder wear due to chemical action. Other manufacturers have turned to the use of porous chrome-plated cylinder bores.

Operating as a division of the Council of Agricultural Technology is the Marburg Tractor Testing Institute (Schlepper Prüffeld Marburg). This government agency cooperates with tractor manufacturers toward improving tractor performance. Tractor manufacturers selling in the world markets are obliged to submit for test any models exported. The results of tests made of tractors sold only in the home market are made public at the discretion of the tractor manufacturers. The Marburg test procedure differs from that of Nebraska in a number of ways, viz.:

1 Engines are removed from the tractor and performance measured with no power losses other than those of the accessories regularly provided.

2 Maximum belt and drawbar performance is corrected to normal temperature and barometric conditions.

3 Tractors are tested as weighted for operation over German soils. Since this soil contains much colloidal material and is sensitive to damage by compaction, the rear tires are not loaded to capacity.

4 Drawbar tests are conducted on a cement roadway, which has a higher traction coefficient than that of the Nebraska test track. This largely eliminates one very disturbing variable from the test procedure. However, the high traction coefficient and low rolling resistance of the cement track gives results which are not directly comparable with Nebraska performance.

5 A hard clay track is available and complete tests are run on this track, although they are not published. The track is swept free from dust, so that variations in traction conditions are minimized. A comparison of tests on the Marburg and Nebraska test tracks show that the performance on both is equivalent.

6 The drawbar-testing equipment gives continuous data as to fuel consumption, injector leak-by, drawbar pull, distance traveled, and slippage of the individual drivewheels. It was interesting to note that this tractor dynamometer was built on an American Dodge army truck.

7 Data is obtained regarding longitudinal and lateral stability, location of the center of gravity, turning radii with and without steering brakes, deceleration due to full brake application, and other performance qualities not evaluated at Nebraska.

It may be parenthetically stated here that the tractor tests to be initiated in Yugoslavia are expected to follow the pattern developed at Marburg with the addition of long field tests to determine durability and deterioration under operating conditions.

Specifications of German tractors officially tested at Marburg have been prepared from available data and are shown in Table 8. The variable-load specific fuel consumption of German tractor engines officially reported from Marburg is shown in Fig. 43.

In Western Germany, there are no "full-line" farm equipment manufacturers who produce both tractors and an integrated line of implements. The greater part of all tractors built are the product of the four largest manufacturers, all of whom have differing backgrounds and interests. The remainder are built by a large number of smaller manufacturers. Some of these build engines, and tractors have been added to provide a greater market for their regular products. Others are completely assembled, using available components such as engines, transmissions, friction clutches, steering gears, radiators, wheels, etc. This condition is reflected in the similar appearance of many such tractors.

Heinrich LANZ of Mannheim was established as a two-man shop in 1859 to manufacture farm implements. Their first steam engine and thresher were built in 1879 and the first farm tractor in 1921. Their background is strictly agricultural. At present they manufacture "Bulldog" tractors, ranging in size from 17 to 55 hp. All are built with single-cylinder horizontal hot-head engines capable of operating on many grades of crude, shale, and peat oils, in addition to refined distillates and diesel fuels. The three smaller models have been officially tested at Marburg and show the lowest specific fuel consumption of any German tractor engines. In addition to tractors, this company manufactures threshers and attachments, straw balers, hay tools, grain binders, beet and potato harvesters, and graders.

Following the pattern established earlier by Munktell in Sweden, Lanz has built tractors with only semidiesel engines. After the last world war, their designs were made available to all who desired them, and manufacturers in France and Italy started to build tractors powered with engines of this kind. Lanz immediately started an engineering program intended to provide quick starting, increase the specific power output, and improve running balance without sacrificing the ability to burn low-cost, high-sulfur fuels. Fig. 44 shows a cross section of their latest type engine. The improvement resulting from this effort is shown in Fig. 45.

Specifications and performance data of the three smaller models are given in Table 8. The engine for the three larger tractors is in the process of being developed along the lines of the smaller engines now in production. At present, these three models are powered with two-cycle semidiesel engines having a bore and stroke of 8.90 by 10.25 in. Output is rated at 35, 45, and 55 bhp at 540, 630, and 750 rpm,

TABLE 8 WEST GERMAN DIESEL WHEEL TRACTORS — DATA FROM OFFICIAL MARBURG TESTS
DECEMBER, 1953

Manufacturer	Hanomag	Hanomag	Hanomag	Hanomag	Hanomag	Fahr	Guldner	Guldner	Stihl
Model	K 55 tracktype	R 45	R 28	R 22	R 16	D 17	AF 15	AF 20	14 PS
Rated brake horsepower	54.3	44.4	27.6	21.7	15.8	16.75	16.75	21.7	13.8
Belt performance									
Maximum horsepower (corrected)	52.2	42.6	25.4	21.2	15.2	15.8	15.8	20.1	12.4
Spec. Fuel Consumption, lb per bhp-hr	0.535	0.510	0.52	0.492	0.500	0.548	0.547	0.504	0.577
Engine									
Type	Four stroke	Four stroke	Four stroke	Four stroke	Four stroke	Four stroke	Four stroke	Four stroke	Two stroke
Fuel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
No. of cylinders	4	4	4	3	2	2	2	2	1
Bore and Stroke	4.33 x 5.90	4.33 x 5.90	3.54 x 4.33	3.54 x 4.33	3.54 x 4.33	3.34 x 4.52	3.34 x 4.63	3.74 x 4.52	3.54 x 4.72
Stroke-bore ratio	1.36	1.36	1.22	1.22	1.22	1.35	1.39	1.21	1.34
Rpm (governed)	1300	1200	1500	1500	1600	1800	1800	1800	1900
Piston Speed fpm	1276	1178	1085	1085	1158	1356	1338	1358	1498
Compression ratio	18:1	18:1	20:1	20:1	20:1	19:1	19:1	19:1	15:1
Combustion chamber	Pre-combustion	Pre-combustion	—	Pre-combustion	Pre-combustion	—	—	Turbulence chamber	Direct Injection
Bmep (lb max)	94.9	91.8	85.4	89.5	88.3	92.8	92.8	95.5	61.8
Starter	12-v	12-v	12-v	12-v	12-v	12-v	12-v	12-v	12-v
Clutch type	Foot operated	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal
Travel speeds, mph									
Forward									
1	1.68	2.18	2.41	2.30	2.30	1.88	1.97	1.86	1.70
2	2.48	3.11	3.26	3.11	2.99	3.48	3.60	3.41	3.02
3	3.73	4.20	4.08	3.91	3.98	4.96	5.18	4.91	4.55
4	—	6.21	7.60	7.21	7.21	7.60	7.88	7.53	8.65
5	—	10.75	12.00	11.39	11.88	12.70	13.10	12.40	—
6	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
Reverse									
1	2.18	1.68	4.35	4.04	—	1.39	1.44	1.37	1.7
2	—	—	—	—	—	—	—	—	—
Differential lock	—	Yes	No	No	No	Yes	Yes	Yes	Yes
Belt pulley									
Location	Rear	Rear	Left side	Left side	Rear	Rear	Rear	Rear	Rear
Diameter, in	19 11/16	16¾	11 13/16	8⅞	10.62	7⅞	7⅞	7⅞	6½
Width, in	7⅞	6 11/16	4 23/32	4 23/32	—	5½	5½	5½	4 23/32
Speed, rpm	572	930	1095	1220	1120	1475	1475	1475	1055 or 1720
Belt speed, fpm	2950	4140	3390	2840	3115	3055	3055	3055	1794 or 2940
Power take-off									
Diameter, in	1⅜	1⅜	1⅜	1⅜	1⅜	1⅜	1⅜	1 11/32	1⅜
Speed, rpm									
1	534	565	556	548	545	537	538	540	528
2	—	—	—	—	—	—	—	—	860
Drive	TD	TD	TD	TD	TD	TD	TD	TD	TD
Tire size, in									
Front	track type 25 29/32	6.50 x 20	6.50 x 20	5.50 x 16	4.50 x 16	5.00 x 16	5.00 x 16	5.00 x 16 5.50 x 16	5.00 x 16
Rear	track type 25 29/32	13.00 x 30	9.00 x 40	8.00 x 36	7-30	8.00 x 24	8.00 x 20	9.00 x 24 10.00 x 24	8.00 x 20 7.00 x 30
Wheel tread									
Front	46.4	54.4	51.2, 55.1,	51.2, 55.1,	51.2, 55.1,	49.2 & 59.1	50.0 & 57.9	50.0 & 57.9	49.6 & 58.5
Rear	46.4	57.0	or 59.1	or 59.1	or 59.1	49.2 & 59.1	50.0 & 57.9	50.0 & 57.9	50.6 & 58.9
Wheelbase, in	72.8	81.8	70.8	66.9	63.0	64.5	61.0	61.0	55.1
Turning radius, min									
Without steering brakes	13′ 1 11/16″	14′	16′ 4⅞″	11′ ⅞″	10′ 6″	8′ 10 5/16″	9′ 8⅛″	9′ 7¼″	10′ 1¾″
With steering brakes	—	11′ 3⅞″	12′ 5¾″	9′ 4¼″	9′ 10″	7′ 6 9/16″	8′ 4½″	8′ 2½″	8′ 8⅜″
Brakes									
Hand	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Foot	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Steering	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Overall dimensions									
Height, less stacks	7′ 2⅝″	6′ 2 13/16″	6′ 10 5/16″	5′ 7/16″	5′ 2⅝″	5′	5′ 6″	5′ 5 1/16″	5′ 2⅝″
Length	10′ 6″	11′ 7⅞″	10′ 3/16″	8′ 11¼″	8′ 9½″	8′ 5 9/16″	8′ 10¼″	8′ 10½″	8′ 4¼″
Ground clearance, min									
Under middle, in	13	12 13/16	16¼	14 15/16	15¾	15¾	13 25/32	16⅛	15¼
Operating weight, (less driver)									
Front, lb	—	2650	1444	1146	—	1124	1235	1200	756
Rear, lb	—	4570	2712	2204	—	1764	1710	1870	838
Total, lb	9920	7220	4156	3350	2575	2888	2945	3070	1594
Percent total weight on front wheels	—	36.8	34.7	34.2	—	39.0	41.9	39.1	47.4
Operating weight per belt horsepower, lb	190	170	164	158	170	183	186	153	129

Manufacturer	Deutz	Deutz	Nordstrak Stier	Lanz Bulldog	Lanz Bulldog	Lanz Bulldog	Fendt	Fendt
Model	F3L514	F2L514	30	D 1706	D 2206	D 2806	F20GH	F25PHI
Rated brake horsepower	41.4	29.6	27.6	16.8	21.7	27.6	20.0	28.0
Belt performance								
Maximum horsepower (corrected)	39.2	28.5	23.9	17.2	21.8	28.1	18.25	26.82
Spec. Fuel Consumption, lb per bhp-hr	0.450	0.468	0.523	0.410	0.418	0.423	0.500	0.504
Engine								
Type	Four stroke	Four stroke	Four stroke	Two stroke	Two stroke	Two stroke	Four stroke	Four stroke
Fuel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
No. of cylinders	3	2	2	1	1	1	1	2
Bore and Stroke	4.33 x 5.51	4.33 x 5.51	3.94 x 5.90	5.11 x 6.70	5.11 x 6.70	5.91 x 8.26	4.41 x 5.91	3.94 x 5.91
Stroke-bore ratio	1.27	1.27	1.50	1.31	1.31	1.40	1.34	1.50
Rpm (governed)	1450	1550	1500	950	1050	850	1600	1600
Piston Speed fpm	1332	1424	1475	1061	1172	1172	1582	1582
Compression ratio	17.3:1	17.3:1	17.3:1	11:1	11:1	11:1	18:1	17.3:1
Combustion chamber	Turbulence chamber	Turbulence chamber	Turbulence chamber	Glow head	Glow head	Glow head	Turbulence chamber	Turbulence chamber
Bmep (lb max)	93.0	94.5	101.0	52.0	59.6	57.7	101.0	93.6
Starter	12-v	12-v	12-v	12-v	12-v	12-v	12-v	12-v
Clutch type	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal	Foot pedal
Travel speeds, mph								
Forward								
1	2.48	2.18	1.52	1.99	2.11	2.10	1.55	1.09
2	3.23	2.92	2.38	2.88	3.07	3.08	2.18	2.11
3	4.22	3.66	4.08	4.24	4.48	4.22	2.79	3.39
4	7.00	7.45	7.35	5.32	5.65	5.28	3.73	4.88
5	12.40	12.40	12.60	7.74	8.24	8.09	4.66	7.03
6	—	—	—	11.30	12.00	10.55	5.13	12.01
7	—	—	—	—	—	—	6.30	—
8	—	—	—	—	—	—	12.42	—
Reverse								
1	1.99	2.79	1.60	3.79	4.03	2.91	1.25	2.61
2	—	—	—	10.15	10.80	8.10	1.86	—
Differential lock	No	Yes	—	No	No	No	Yes	Yes
Belt pulley								
Location	Right side	Rear	Rear	Right side	Right side	Right side	Rear	Rear
Diameter, in	14 3/16	8 21/32	9 7/16	13	13	21¼	8⅞	8.65
Width, in	6 11/16	5⅛	5⅛	4 15/16	4 15/16	5 29/32	5 29/32	5.11
Speed, rpm	900	1520	1260	950	1050	850	1470	1573
Belt speed, fpm	3340	3440	3120	3230	3560	4730	3420	3560
Power take-off								
Diameter, in	1⅜	1⅜	1⅜	1⅜	1⅜	1⅜	1⅜	1⅜
Speed, rpm								
1	540	558	560	545	560	555	583	575
2	—	—	—	—	—	—	—	—
Drive	TD	TD	TD	TD	TD	TD	Independent	TD
Tire size, in								
Front	6.00 x 20	5.50 x 16	9.00 x 24	4.50 x 16	5.50 x 16	6.00 x 20	5.00 x 16	6.00 x 20
Rear	13.00 x 30	11.00 x 28	9.00 x 24	7.00 x 36	8.00 x 36	9.00 x 40	6.50 x 32	9.00 x 40
Wheel tread								
Front	53.4	42.9 & 59.1	42.9 & 59.1	47.2 to 61.5	47.2 to 61.5	47.2 to 56.9	49.2 & 56.3	51.5 & 58.5
Rear	55.1	42.9 & 59.1	42.9 & 59.1	47.2 to 61.0	47.2 to 61.0	47.2 to 70.8	49.2 & 57.1	50.0 & 57.1
Wheelbase, in	81.5	68.6	66.3	65.7	69.6	71.8	62.6	73.6
Turning radius, min								
Without steering brakes	13′ 1¼″	11′ 6″	14′ 7¼″	11′	11′ 6″	11′	9′ 6″	11′ 9″
With steering brakes	9′ 10¼″	9′ 6½″	12′	9′ 6¼″	9′ 8⅜″	9′ 10¼″	8′ 5″	9′ 10″
Brakes								
Hand	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Foot	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Steering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Overall dimensions								
Height, less stacks	6′ ¾″	5′ 8″	6′	6′ 1″	6′ 1¼″	6′ 2½″	5′ 6″	5′ 1¾″
Length	10′ 1⅛″	9′ 3⅛″	9′ 7⅛″	8′ 11½″	9′ 3½″	10′ 7/16″	9′ 9″	10′ 5″
Ground clearance, min								
Under middle, in	15 3/16	15¾	12 13/16	15 15/16	16 17/32	16 11/32	15¾	18.3
Operating weight, (less driver)								
Front, lb	1775	1300	2415	1025	1041	1702	1265	1410
Rear, lb	3306	2514	2425	1875	1989	3214	1815	2890
Total, lb	5181	3814	4830	2900	3030	4916	3080	4300
Percent total weight on front wheels	34.3	34.1	50.0	35.4	34.4	34.7	41.0	32.8
Operating weight per belt horsepower, lb	132	134	202	169	139	175	167	159

respectively. Fig. 46 shows the 28-hp Lanz "Bulldog" tractor, with wheels adjusted to the maximum 78¾-in tread.

The most recent Lanz development is their "Alldog" general-purpose tractor or "implement carrier." (Table 9 gives brief specifications.) The rear view is shown in Fig. 47 and a front view with a mounted mower and a winch is shown in Fig. 48. In order to mechanize at the lowest cost and avoid the replacement of animal-drawn implements now on farms, Lanz provides detailed instructions for mounting

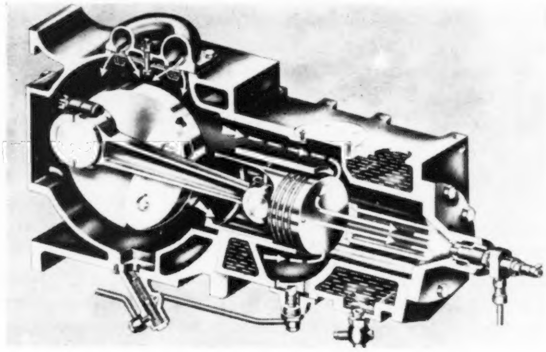


Fig. 44 Cross section of Heinrich Lanz tractor

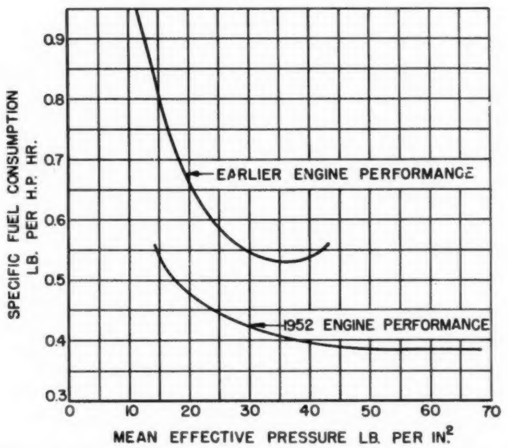


Fig. 45 Improvements resulting from redesign of Heinrich Lanz engine performance

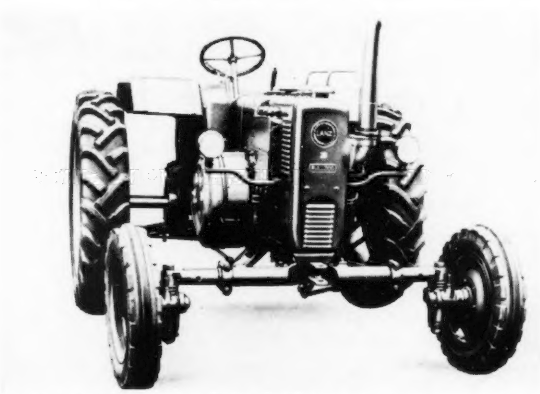


Fig. 46 Heinrich Lanz 28-hp "Bulldog" tractor with wheels adjusted to maximum tread

TABLE 9. LANZ "ALLDOG" IMPLEMENT CARRIER GENERAL SPECIFICATIONS

Engine	
Manufacturer	Triumph-Werke, A. G. Nürnberg
Type	Single-cylinder, semidiesel, two-cycle air-cooled, reverse scavenged
Power, bhp	12
Speed, rpm	3000
Bore and stroke, in	3.35 x 3.73
Piston speed, fpm	1865
Compression ratio	12:1
Weight (with starter and generator), lb	145
Travel speeds, mph	
First	1.6
Second	2.9
Third	4.7
Fourth	7.5
Fifth	12.00
Reverse	2.4
Power take-off	
Front and rear, in	1⅜, 6 spline
Optional PTO from right-hand front wheel synchronized with tractor speed	
Brakes	Individual rear wheel locked by hand lever
Front wheels	
Tires	5.50 x 16
Treads, in	49, 59, 65, 70, 74, 79
Rear wheels	
Tires	7—24 on W6—24 rims
Treads, in	49, 59, 65, 74, 75½, 79
Starting	Hand with electric optional
Power lift	Hydraulic
Steering	Front-wheel linkage, optional steering adjustment of rear axle to avoid side slip on hillside
Belt Pulley, in	8½ diameter x 5⅞ face
Fuel	Diesel fuel with 5 percent gasoline added
Weights and dimensions	
Over-all length	11 ft 11¾ in
Over-all width	
Maximum	7 ft 2 in
Minimum	5 ft 3¾ in
Overall height (max)	5 ft 7¾ in
Ground clearance	
Tractor hitch	22½ in
Implement hitch	17⅜ in
Turning radius, min	8 ft 6⅝ in
Operating weight, lb	2580

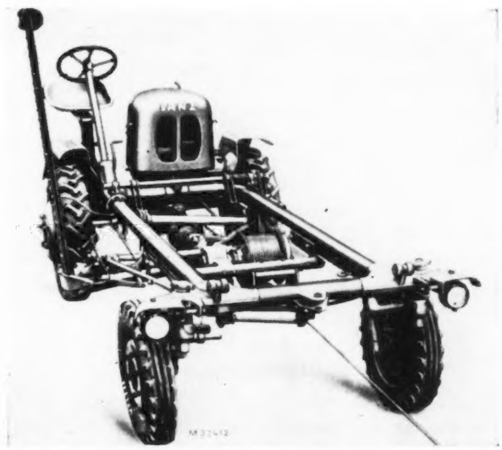


Fig. 47 Front view of Heinrich Lanz "Alldog" implement carrier with mounted mower and winch

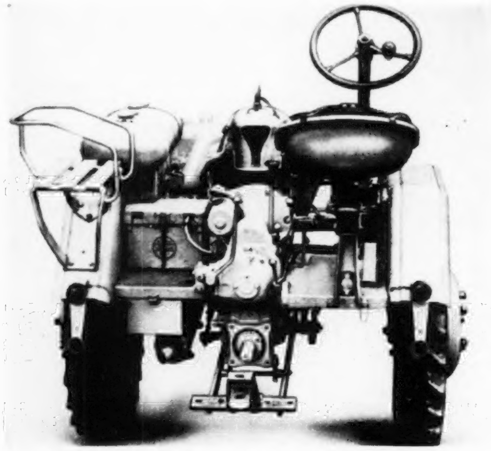


Fig. 48 Heinrich Lanz "Alldog" implement carrier

the many makes of existing German implements to the "Alldog." The front wheel oscillates with the frame around a pivot at the rear, so as to pass over the roughest ground. The spindles of the front-wheel knuckles are pivoted in independently adjustable swinging arms, which permits adjusting the front-wheel tread as required for varying field conditions, and also to allow "running over" implements which are supported below the tubular-frame members. As soon as these underslung implements are attached, the working tread is restored.

The Lanz effort to develop a tractor which is capable of replacing animal power on the small family farms of Western Germany is comparable with the task facing American tractor builders in the middle 1920's. However, the job is being undertaken in cooperation with the nation's leading implement manufacturers. Already implements are available for performing 48 different farm operations, including those pertaining to both domestic and export farming areas. However, the problem of quickly and easily removing all of these implements remains difficult and has not yet been fully resolved.

REFERENCES

1 The European Tractor Industry in the Setting of the World Markets, United Nations Economic Commission for Europe, E/ECE/139-E/ECE/IM/57.

2 *Farm Implement News*, 1953 Statistical Issue.

3 *Automobile Engineer*, November, 1951.

4 Etudes du Service de la Documentation sur le Mechanisme Agricole, Directior Génerale du Genie Rural et de ('Hydraulique Agricole Etude Nos. 100, 102, and 103).

5 Die Schlepperendustrie im Jahre 1952, von Friedrich Keihn, Landtechnik, Heft 5, Jahrgang 8.

6 Automobiletechnische Zeitschrift, 55 Jahrgang, Heft 5, 1953.

(To be concluded in the June issue)

Parallel Rows and Parallel Terraces

(Continued from page 310)

Case III. In this case, $H=100\ L\ (G-g)/(S_2-S_1)$ and S_2-S_1 soon becomes negative as it did in Case II. However, in Case III it may be practical under some circumstances to provide an outlet for rows down slope from H_0, and to continue the rows until the maximum permissible grade is reached.

Case IV. For this case, $H=100\ L\ (G-g)/(S_1-S_2)$. S_1-S_2 is always positive as in Case I. An example of the combined effects of Case III and Case IV (using two outlets in Case III) is given in Table 3.

TABLE 4. Combined Distances Up and Down Slope and Guide Terrace, Case III and Case IV

$G=2.5$ $g=0.4$

	Values of L		
S_1-S_2	$L=1$	$L=3$	$L=5$
1	460	1,380	2,300
2	230	690	1,150
3	153	460	767
4	115	345	575
5	92	376	460

It is evident that parallel rows and parallel terraces are applicable to fairly wide fields with moderately long rows, short slopes, and with little variation in the percent of slope. Such fields are common in the southeastern Coastal Plain and are all too commonly farmed without necessary erosion control measures. The new method should eliminate many of the objections to previously proposed methods and should result in a decided increase in contour cultivation in this section.

The method can be developed to include parallel strips, for strip cropping. Steeper fields than originally contemplated — having, however, smooth topography and little difference in slope — could also be strip-cropped advantageously by this method.

It is also applicable to the working out of row-drainage patterns on wet lands, and to row layout furrow irrigation.

Rationalizing Analysis in Design

(Continued from page 306)

characterized by a swinging motion of the vine with only an occasional fruit being removed.

The significance of this result may not be at once obvious. However, assuming most of the fruit is concentrated at the lower end of the suspended vine and applying the expression for the simple pendulum, the solution yields the pendulum length. This compares very closely with the recorded measurements of the vines themselves.

The foregoing examples represent a few of the problems encountered in work in the field of agricultural engineering. They have been used not only to present some of the details of the types of machines classed as specialty equipment but to illustrate and emphasize the different elements of a system of thinking important to deriving a workable solution.

A Correction

ONE of the authors calls attention to a typographical error in the article, entitled "A Slide Rule for Soil Moisture Determinations," beginning on page 163 of AGRICULTURAL ENGINEERING for March, 1954. The error occurs in the second sentence of the second paragraph beginning on page 164. This sentence states that the temperature scale "was constructed from 67F each way . . ." The correct figure is *60F*.

Practical Experiences with Alcohol-Water Injection in Trucks and Farm Tractors

Richard Wiebe and John D. Hummell

SINCE the publication of the previous paper entitled "Alcohol-Water Injection for High-Compression Tractor and Automobile Engines" (**1**),* additional results have been obtained showing the adaptability of injection to practical operation. In 1950, the Fuels and Lubricants Section, Office of Chief of Ordnance, undertook at the suggestion of the Northern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry, a truck test at Aberdeen Proving Ground, Aberdeen, Md., in which two trucks were operated with injection and one without†.

Arrangements were also made with the department of agricultural engineering of the Ohio Agricultural Experiment Station under a Research and Marketing Act contract to supervise the operation of 50 tractors having compression ratios from 5.3:1 to 8:1 on farms in the Columbus, Ohio, area. The effectiveness of alcohol-water injection in raising the octane number of gasolines was demonstrated both at Aberdeen and Columbus.

It appeared in the extensive laboratory and field work that injection may not only raise the effective octane number of the gasoline but also may improve engine performance in general. Since lubrication is one of the factors affecting over-all engine performance, it was decided to study four premium-type lubricating oils with and without injection, by two standard test procedures. This work was undertaken by the Armour Research Foundation under another Research and Marketing Act contract with the Northern Regional Research Laboratory. The results of the three studies outlined above will be presented in this paper.

Aberdeen Proving Ground Test‡

The purpose of this test program was to obtain information on the application and effect of injecting alcohol-water mixtures in engines in military vehicles requiring 80 octane (Motor Method)§ fuel but using 68 ON (octane number) fuel. It was felt, however, that the results would also have more general significance.

The plan consisted of driving three 2½-ton trucks of 270-cu-in displacement at double the rated pay load (10,000 lb) on paved and gravel roads, as well as on cross-country terrain at Aberdeen Proving Ground, for 12,000 miles or until engine failure occurred in any one of the vehicles. Exhaust valves were of the standard non-rotating type. An average MIL-2-104B oil was used and both filter cartridge and oil were changed at 5,000-mile intervals. Before the test the engines were disassembled for inspection, bearing and piston weights determined, and carburetors cali-

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, as a contribution of the Power and Machinery Division. It reports work done under three contracts with the U.S. Department of Agriculture and authorized by the Research and Marketing Act of 1946. The contracts were supervised by the Northern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry.

The authors — RICHARD WIEBE and JOHN D. HUMMELL — are, respectively, head, motor fuels evaluation division, Northern Regional Research Laboratory, U.S. Department of Agriculture, and agricultural engineer, Ohio Agricultural Experiment Station.

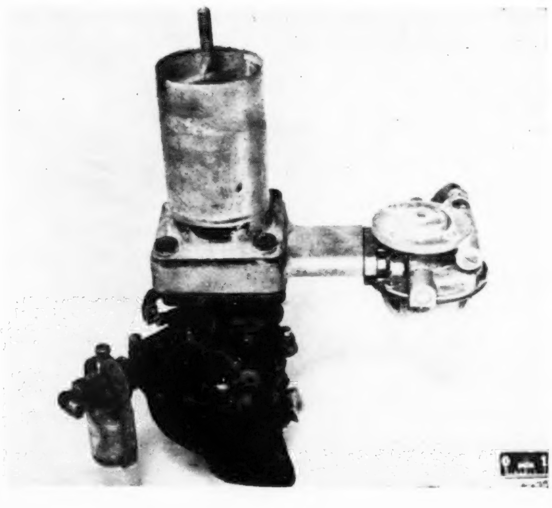
Author's Acknowledgment: At the Northern Regional Research Laboratory the help of A. P. McCloud and M. M. Gilbert, and particularly that of J. C. Porter in assisting in the work at Columbus and Aberdeen and advising the contractors at various times, is herewith gratefully acknowledged.

*Bold-faced numbers in parentheses refer to the references appended to this paper.

†Work accomplished with the cooperation of the U.S. Department of the Army, office of chief of ordnance. The Bureau of Agricultural and Industrial Chemistry, U.S. Department of Agriculture, contributed funds available under the Research and Marketing Act of 1946.

‡Based on the formerly "restricted" reports issued on Project TB 5-0010F which have recently been "unclassified."

§Octane numbers are specified in two ways: Research octane number (ASTM D908-51) and motor octane number (ASTM D357-48). Generally the research number satisfies the low-speed engine octane requirement while the motor number does it at high speeds.



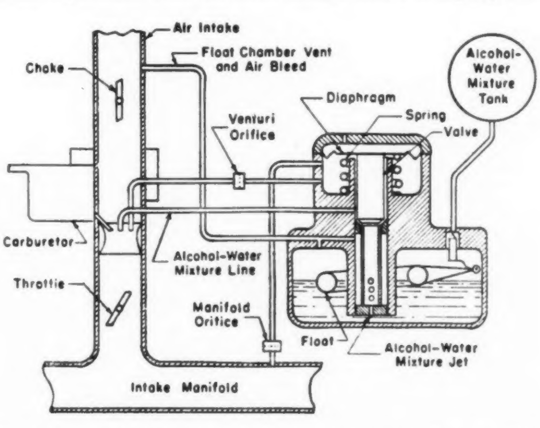


Fig. 1 *(Left)* Alcohol-water injection equipment installed on carburetor of GMC model 270 engine • Fig. 2 *(Above)* Schematic drawing of alcohol-water injector

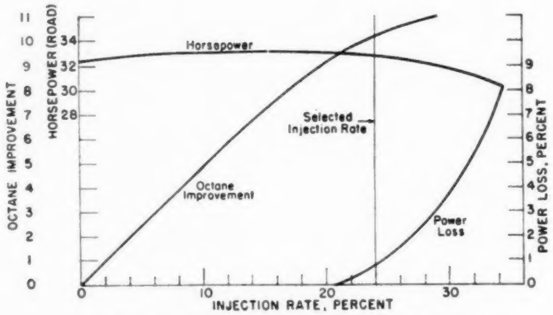


Fig. 3 Alcohol-water injection rate determination

brated for equal rates of flow at a given manifold vacuum. After assembly and installation the trucks were driven 500 miles for breakin. To check for differences in road-rolling resistance, the fully loaded truck (10,000 lb) was towed with its transmission in neutral at 20 and 27 mph on smooth rolling terrain by using a drawbar dynamometer, and the drawbar pull was recorded. One truck, No. 205, was run with a prototype 80 ON combat grade fuel conforming to specifications MIL-G-3056 but with 0.3 percent of sulfur, plus 35 lb per 1,000 bbl of an oxidation inhibitor, and from 2.52 to 3.12 ml tetraethyl lead per gallon. The second truck, No. 241, used a straight-run 67-69 octane gasoline in combination with alcohol-water injection, while a third truck, No. 631, was first operated with the above 80 ON gasoline over a distance of 2,541 miles and from there on with 68 ON straight-run gasoline plus injection. A 50:50 denatured grain alcohol-water mixture containing a small amount of corrosion inhibitor was used throughout the program. Fig. 1 shows the flange-mounted injector above the carburetor with schematic details shown in Fig. 2.

The operation of this particular injector depends on the change in manifold and venturi vacuum with speed and load. When a certain vacuum is reached, usually around 5 to 7 in Hg, this pressure (23 to 25 in Hg abs) in combination with a calibrated spring will lift the diaphragm and open the mixture valve. In order to prevent injection at high speeds where the octane requirement is low, two vacuum control lines are required, one leading from the

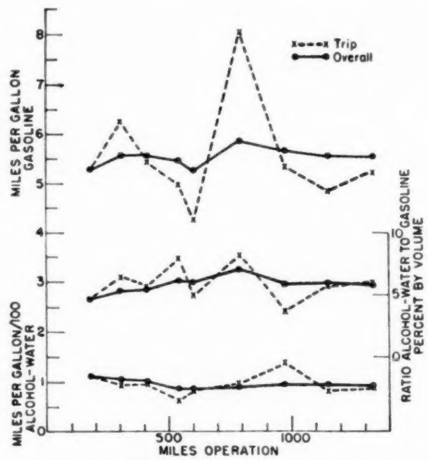


Fig. 4 Log chart of gasoline and alcohol-water consumption for truck 241

manifold, the other from the venturi. For obtaining a proper balance, two orifices are placed in the two vacuum lines. At full throttle and low speed, atmospheric pressure is not able to overcome the triple action of manifold, venturi and spring pressures. As the engine speed increases, the venturi vacuum increases, reducing the pressure opposing that of the atmosphere sufficiently to close the injection valve while the manifold vacuum still remains low. Proper vacuum-control orifices and spring combination must be selected for each engine to give best economy with the type of gasoline used.

Before starting actual tests two trucks were placed on a chassis dynamometer and the injection requirements were determined by means of a burette, noting the knock die-out under various load conditions. Typical results plotted in Fig. 3 show (*a*) variation of full-throttle horsepower at 1,000 rpm with injection rate, (*b*) loss of full-throttle horsepower as a function of injection rate, and (*c*) octane improvement vs. injection rate. Curves of loss of full-throttle horsepower indicate that overinjection may lead to an appreciable power loss. Octane improvement is prac-

TABLE 1. OCTANE REQUIREMENTS WITH MILES OF OPERATION

Vehicle number	Octane requirement, miles of operation: Without injection, Miles	Without injection, ON	With injection, Miles	With injection, ON	Octane increase with injection	Remarks
205	0	78				On prototype fuel
	717	77				
	1,167	82				
	2,470	82				
	6,326*	81				
	8,861**	-				
241	0	84	0	71	13	Straight run plus injection
	1,334	86	1,334	-	-	
	1,833	81	1,833	66	15	
	4,428	84	4,428	74	10	
	6,040	86	6,040	73	13	
	8,094	-	8,094	-	-	
631	0	79	-	-	-	On prototype fuel
	1,517	88	-	-	-	
	2,541	87	-	-	-	
	-	-	2,541	77	10	On straight run plus injection
	4,079	84	4,079	74	10	
	5,848	84	5,848	73	11	
	7,615	-	7,615	-	-	

* Exhaust-valve failure, new valves installed without disturbing combustion-chamber deposits

** Second exhaust-valve failure--ended run.

TABLE 2. SUMMARY OF ABERDEEN TEST DATA

	Truck 205	Truck 241		Truck 631	
Miles of operation over -					
Paved road	3,310	2,824		2,575	
Gravel road	4,808	4,750		4,178	
Cross-country road	743	520		862	
Total miles	8,861	8,094		7,615	
Gasoline consumption in miles per gallon -					
Paved road	5.4	5.3		5.1	
Gravel road	4.5	4.5		5.0	
Cross-country road	2.2	1.9		2.1	
Alcohol-water mixture consumption -		Miles per gallon	Percent of gasoline	Miles per gallon	Percent of gasoline
Paved road		78	6.8	90	5.6
Gravel road		52	8.6	52	8.7
Cross-country road		20	9.9	22	9.7

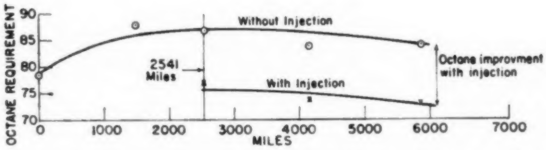


Fig. 5 Change in octane requirement with miles of operation for truck 631

tically linear up to 20 percent injection and from there on more injection is needed for the same octane gain. Since a minimum gain of 10 octane numbers was desired, final injection rate was set at 24 percent for full-throttle operation at 1,000 rpm. This was the point of maximum requirement. Test data showed octane improvement as high as 15 units.

During the road tests, octane requirements with and without alcohol-water injection were determined by means of the modified CRC-E-1 procedure (Modified Uniontown Method) at approximately 1,700-mile intervals (Table 1). This procedure consists of accelerating the truck at wide open throttle in a gear which gives acceleration from 500 to 2,500 rpm in 20 to 40 sec. These runs were made with a series of primary reference fuels (blends of isooctane with n-heptane) having octane numbers 2½ units apart. The "knockin" and the "knockout" points were recorded for each blend. A curve drawn through the "knockout" points gives the octane requirement vs. speed.

The trucks were operated over a course consisting of *(a)* a bituminous concrete highway for approximately 40 percent, *(b)* a Munsen gravel road for about 50 percent, and *(c)* the "Churchville cross-count.y drive" for less than 10 percent of the total mileage. Exact mileages are given in Table 2, which summarizes the test results. Adverse weather conditions at Aberdeen necessitated prolonged rest periods and frequently very short runs. This is illustrated in Fig. 4 which is a log chart for runs made between October 10 and 19, 1950, which varied in length from 60 to 191 miles. Individual trip and cumulative over-all mileage results are given for alcohol mixture and gasoline consumption. The over-all results for this series of runs indicate 89 mpg (miles per gallon) of mixture and 5.3 mpg of gasoline. From these figures the percentage of mixture to gasoline is calculated as 5.9 percent, but it is well to keep in mind that only half of it is alcohol. Considerable variation in consumption occurred at various times as shown, for instance, at the 800-mile point. Final averages are given in the aforementioned Table 2 under "gasoline consumption" and "alcohol-water consumption" for each of the three courses. As was to be expected, in view of the calibration of the carburetors, there was no essential difference in gasoline consumption with and without injection, at least not within the experimental accuracy of the results.

In Fig. 5 the octane requirement, with and without injection, of truck No. 631 is plotted against mileage. As will be recalled, this truck was operated on gasoline alone for the first 2,541 miles and then with injection for the remainder of the test (Table 1). The difference between the curves equals the octane improvement with injection. There was an initial increase of 8 octane numbers in the octane requirement of engine No. 631 and then a drop of 3 numbers during the injection period, indicating a possible beneficial action of injection on combustion-chamber deposits. No general conclusion can be based on these results since the octane requirements both of trucks 205 and 241 increased only 3 and 2 numbers, respectively.

At the end of the test (second exhaust valve failure in truck No. 205) all three engines were disassembled and carefully inspected. All inlet valves were in excellent condition at the end of the test except for slight deposits on tulips on inlet valves of truck No. 205 operated on prototype gasoline. Exhaust valves in truck engine 205 had

TABLE 3. SPECIFICATIONS OF THE ENGINES USED TO OBTAIN THE FIELD-TEST DATA

Tractor make	A	B	B_1	C	D
No. of cylinders	4	4	4	6	4
Bore, in	4.00	3.87	3.375	3.31	4.25
Stroke, in	4.00	5.25	4.25	3.75	5.00
Displacement, cu in	201	248	152	194	284
Rated speed, rpm	1,400	1,450	1,650	1,600	1,275
Rated hp at standard compression ratio	30.4	33.4	23.7	33.0	38.4
Compression ratio and no. used for tests -					
Standard	5.7:1 (5)* or 5.5:1	5.6:1 (9)	5.9:1 (3)	6.8:1 (3)	5.3:1(5)
Optional	6.6:1 (3)	6.5:1 (6)	6.8:1 (1)		6.8:1(5)
Optional	8.0:1 (3)	7.8:1 (5)	4.7:1 (1)		7.9:1(2)
Method used to obtain optional ratios	Combination of pistons and rods	Change pistons	Change pistons		Change heads

* Numbers in parentheses indicate the number of tractors used in the test.

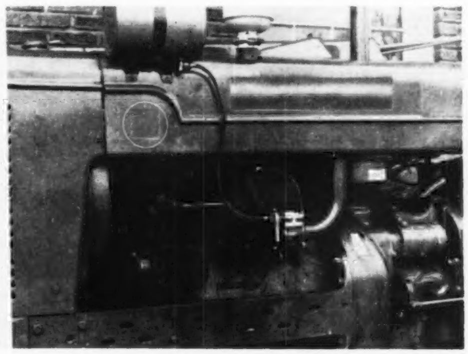


Fig. 6 *(Left)* Typical piston of engine of truck 205 operated for 8861 miles on prototype gasoline without alcohol-water injection • Fig. 7 *(Center)* Typical piston of engine of truck 241 operated for 8094 miles on 68 octane gasoline with alcohol-water injection • Fig. 8 *(Right)* Typical alcohol-water injector installation on a farm tractor

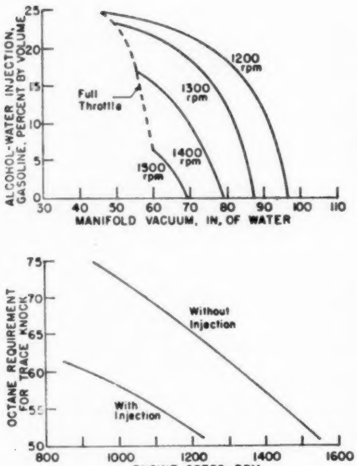


Fig. 9 Injection and octane requirements of a tractor engine of 5.7:1 compression ratio

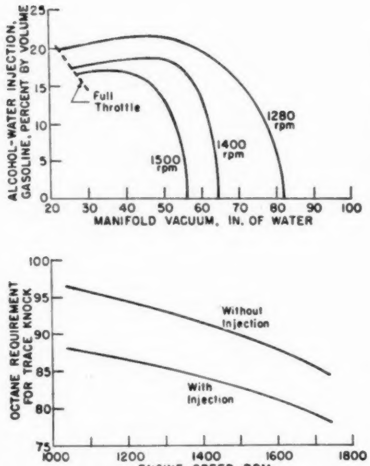


Fig. 10 Injection and octane requirements of a 7.8:1 compression ratio tractor engine

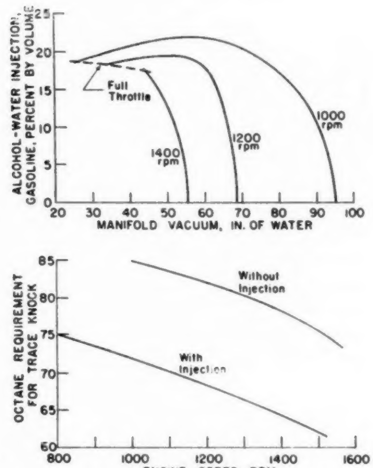


Fig. 11 Injection and octane requirements of a tractor engine of 6.8:1 compression ratio

deteriorated at the end of 6,326 miles to the extent that it became necessary to install a new set. This happened again after an additional 2,535 miles when the test was terminated. The exhaust valves of engine in truck 241 were found to be seating satisfactorily after 8,094 miles. Comparison of typical pistons from the same two engines (Figs. 6 and 7) clearly indicate the advantage of injection with a straight-run fuel. Oil rings of truck engine No. 205 (Fig. 6) were plugged to the extent of 14 percent which is not excessive, while in the other two trucks plugging amounted to only 8 to 10 percent (Fig. 7).

There was a noticeably higher level of sludge, varnish and combustion chamber deposits in truck engine 205 than in the other two. It was interesting to note that engine 631 had lost most of the prototype-gasoline sludge during operation with injection and a straight-run gasoline. Bearing-weight loss was found negligible in all three engines; however, cylinder wear was 73 and 75 percent less for truck engines 241 and 631, respectively, than for No. 205 using gasoline alone.

TABLE 4. PROPERTIES OF FUELS AVAILABLE IN THE COLUMBUS, OHIO, AREA

Fuel type	Approx. distillation (deg F) 10 percent	50 percent	EP	Reid vapor pressure	Approximate ON level
Distillate	375	410	530	0.0	20
Tractor fuel	185	350	520	8.0	40
Straight run	160	200	350	8.0	60
Regular-grade commercial	100	240	420	Seasonal	88*
Premium-grade commercial	100	240	420	Seasonal	92*

* Research octane number: In the low octane range the difference between Motor and Research ratings for most commercial fuels is zero or nearly so.

The conclusions drawn from this test are that it is feasible and advantageous to use alcohol-water injection when it is necessary or economical to operate an engine on a gasoline of octane number lower by 10-12 units than that normally required by the engine. Operation with injection results in suppressed knock, cleaner engines, and less cylinder wear. No saving of fuel was realized since all carburetors were set at equal flow rates. If advantage could be taken of the heating value of alcohol by proper adjustment of air-fuel ratios, some economy should result.

Ohio Agricultural Experiment Station Test**

During 1951 and 1952 the department of agricultural engineering of the Ohio Agricultural Experiment Station, under contract with the Northern Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, supervised the operation of 50 tractors on farms in the Columbus, Ohio area, in

**The work was carried out under the general direction of G. W. McCuen, chief, agricultural engineering department, Ohio Agricultural Experiment Station, and the direct supervision of John D. Hummell. The data are taken from Mr. Hummell's final report.

TABLE 5 SUMMARY OF THE FUEL CONSUMPTION AND HOURS OF OPERATION OF THE TRACTORS USING ALCOHOL-WATER INJECTIOF

Name	Comp. ratio	Gasoline, gal	Alcohol-water gal	Hours	Gallon gasoline per hour	Injection	Type of work
Mr. P	8.0:1	457	15.8	330	1.31	3.46	General
		332	48.6	155	2.14	14.60	Seedbed
		789	64.4	485	1.62	8.15	Total
Mr. P	7.8:1	613	7.3	356	1.72	1.19	General
		723	71.5	305	2.37	9.90	Seedbed
		1,336	78.8	661	2.02	5.90	Total
Mr. A	5.6:1	390	46.4	152	2.56	11.90	Seedbed and Total
Mr. H	5.3:1	397	3.8	267	1.49	0.96	General
		122	1.1	58	2.10	.90	Seedbed
		519	4.9	325	1.60	.94	Total
Mr. N	8.0:1	607	13.1	528	1.15	2.16	General
		679	35.0	402	1.69	5.17	Seedbed
		1,286	48.1	930	1.38	3.75	Total
Mr. Y	8.0:1	191	1.1	138	1.38	0.58	General
		230	9.4	102	2.26	4.07	Seedbed
		421	10.5	240	1.75	2.50	Total
Mr. Y	6.6:1	92	0.8	49	1.88	0.88	General
		394	21.8	167	2.36	5.54	Seedbed
		486	22.6	216	2.25	4.65	Total
Mr. J	6.6:1	485	8.0	533	0.91	1.65	General
		227	18.5	132	1.73	8.15	Seedbed
		712	26.5	665	1.07	3.72	Total
Mr. J	5.7:1	659	13.8	665	0.99	2.06	General
		319	20.0	235	1.36	6.26	Seedbed
		978	33.8	900	1.09	3.46	Total
Mr. D	5.5:1	487	2.5	381	1.28	0.51	General
		288	15.2	151	1.91	5.28	Seedbed
		775	17.7	532	1.46	2.28	Total
Mr. D	5.7:1	393	2.1	387	1.02	0.53	General
		378	13.8	234	1.62	3.65	Seedbed
		771	15.9	621	1.24	2.06	Total

TABLE 6. SUMMARY OF THE FIELD-TEST DATA ACCORDING TO THE VARIOUS TRACTOR MAKES AND COMPRESSION RATIOS

No. of tractors	Comp. ratio	Gasoline, gal	Alcohol-water, gal	Hours	Gasoline, gal per hr	Injection, %
			A			
3	8.0:1	2,496	123.0	1,655	1.50	4.94
3	6.6:1	1,824	59.7	1,396	1.31	3.27
5	5.5-5.7:1	4,083	83.3	3,345	1.22	2.04
11	5.5-8.0:1	8,403	266.0	6,396	1.31	3.16
			B			
5	7.8:1	5,256	214.5	2,785	1.89	4.07
6	6.5:1	6,006	217.9	4,163	1.44	3.62
9	5.6:1	6,236	256.7	3,720	1.68	4.10
20	5.6-7.8:1	17,498	689.1	10,668	1.64	3.94
			B_1			
1	6.8:1	1,178	88.0	992	1.33	7.50
4*	5.9:1	1,729	81.2	1,585	1.09	4.70
5	5.9-6.8:1	2,907	169.2	2,577	1.13	5.80
			D			
2	7.9:1	2,304	49.3	1,305	1.76	2.14
5	6.8:1	3,769	147.4	2,245	1.68	3.91
5	5.3:1	4,819	193.4	2,609	1.85	4.01
12	5.3-7.9:1	10,892	390.1	6,159	1.77	3.58
			C			
3	6.8:1	2,119	77.5	1,285	1.65	3.66

* This number includes one tractor of 4.7:1 compression ratio.

order to translate previous (1) laboratory data obtained at the Laboratory into practice. Under the provisions of the contract each cooperating farmer was furnished a calibrated injector, a drum of a specially denatured 50:50 alcohol-water mixture, an hour meter, in some instances high-compression pistons or cylinder heads, and instructed in the plan and purpose of the work. In turn, he was required to maintain records of gasoline and alcohol-water consumption, hours of operation, types of operation, and, in general, to give his impressions regarding operation of tractors with injection. Table 3 gives the specifications of the tractors used in the test.

The type of injector used is shown schematically in Fig.

TABLE 8. FUEL CONSUMPTION, HOURS OF OPERATION AND ANALYSES OF THE COMBUSTION-CHAMBER DEPOSITS FOR THE INSPECTED ENGINES

Tractor owner	Mr. P	Mr. Y	Mr. H	Mr. P	Mr. F	Mr. S	Mr. W	Mr. E	Mr. W
Tractor make and model		A			B			D	
Compression ratio	8.0:1	6.6:1	5.5:1	7.8:1	6.5:1	5.6:1	7.9:1	6.8:1	5.3:1
Hours of operation	485	216	702	661	640	593	604	539	629
Gallons of gasoline	789	486	89 reg. 799 white	1,336	1,079	940	1,063	928	1,067
Gallons of alcohol-water used	64.4	22.6	12.6	78.8	26.5	35.4	15.0	24.5	43.6
Grade of gasoline	Prem.	Reg.	White	Prem.	Reg.	Reg.	Reg.	Reg.	Reg.
				Combustion-Chamber Deposits					
Dry weight, g	57.35	24.13	15.00	32.2	66.37	96.25	16.1	52.79	86.85
Pb, %	54.6	60.65	28.79	56.12	45.76	50.14	35.18	45.80	55.20
C, %	9.93	8.18	36.15	7.33	22.11	18.42	23.28	22.77	13.92
H, %	1.00	0.69	2.91	0.73	1.84	1.61	1.31	1.88	1.05
S, %	1.90	0.69	2.77	2.29	2.91	1.34	1.63	1.63	2.49
Si, %	0.11	0.00	0.10	0.01	0.15	0.12	0.10	0.00	0.22
Fe, %	0.53	0.73	1.44	2.31	0.93	0.71	-	0.48	0.71

TABLE 7. SUMMARY OF THE FIELD-TEST DATA ACCORDING TO THE COMPRESSION RATIOS OF THE ENGINES - ALL MAKES OF TRACTORS

No. of tractors	Comp. ratio	Gasoline, gal	Alcohol-water, gal	Hours	Gasoline, gal per hr	Injection, %	Type of work
10	7.8-8.0:1	4,302	67.0	3,126	1.38	1.56	General
10	7.8-8.0:1	5,754	319.8	2,619	2.20	5.56	Seedbed
10	7.8-8.0:1	10,056	386.8	5,745	1.75	3.86	Total
(17)	6.5-6.8:1	6,493	123.9	5,847	1.10	1.90	General
(17)	6.5-6.8:1	7,464	449.6	3,740	1.99	6.01	Seedbed
18	6.5-6.8:1	14,896	490.5	10,071	1.48	3.97	Total
(20)	5.3-5.9:1	8,079	135.8	6,988	1.26	1.54	General
(19)	5.3-5.9:1	7,058	444.4	3,445	2.05	6.30	Seedbed
23*	5.3-5.9:1	16,867	614.6	11,359	1.49	3.65	Total
(47)	5.3-8.0:1	18,874	326.7	15,961	1.18	1.72	General
(46)	5.3-8.0:1	20,276	1,213.8	9,794	2.05	6.00	Seedbed
51	5.3-8.0:1	41,819	1,591.9	27,175	1.54	3.80	Total

* This includes one 4.7:1 compression ratio tractor.

2 and installed in Fig. 8. Fig. 2 shows a downdraft carburetor, but the principle is naturally the same for the updraft type. Since the speed range of tractors is quite narrow, the venturi control which prevents unnecessary injection at high speeds, may not be as important as in the higher speed car and truck engines; however, it was used in the test program and does contribute to economy.

At the start of the program the injection requirement vs. manifold vacuum (load) and octane gain vs. speed at full throttle for trace knock were determined for each tractor make and model. Fig. 9 gives these data for a tractor of compression ratio 5.7:1. As shown in the upper graph, injection requirement breaks sharply with increase in speed. Tractors operate under peak injection requirement conditions relatively seldom, and then for only brief periods, so that the maximum injection of 25 percent fortunately is needed only rarely. Average injection amounted to only 4 percent of the gasoline consumed as will be shown later. The maximum octane requirement of this tractor at 1,200 rpm is approximately 66 (lower graph). With a gain of 14 octane numbers with injection this tractor could therefore be operated on a 52 octane straight-run fuel. Properties of

TABLE 9. OUTLINE OF TEST CONDITIONS

L-4 Test *	FL-2 Test *
Time: 36 hours Engine speed: 3,150 rpm ±25 Engine load: 30 bhp, ±1 Jacket coolant temperatures - Outlet: 200 F, ±2 F Inlet: 190 F, min Oil sump temperatures - SAE 30 and 50: 280 F, ±2 F SAE 10--10W : 265 F, ±2 F Air-fuel ratio: 14.5 to 1, ±0.5 Oil change: None during 36-hr test period	Time: total operating time, 40 hr (There should be at least two 4-hr shutdowns during the 40-hr test period and not more than five such shutdowns.) Speed: 2,500 rpm, ±25 Load: 45 hp, ±1 Jacket coolant temperature - Outlet: 95 F, ±5 F Inlet: 85 F, ±2 F Crankcase oil temperature: 165 F, ±5 F Air-fuel ratio: 14.5, ±0.5 Oil change: 3 3/4 qt plus ½ pt put in dip troughs during engine assembly.

Prior to each test the engine is carefully cleaned so that any sludge or varnish deposits formed during the test run will be readily apparent.

* For the alcohol-water injection tests, an 85:15 alcohol-water mixture was injected at the rate of 25 percent by volume of the total fuel consumed.

fuels sold in the Columbus, Ohio, area are shown in Table 4. Fig. 10 gives similar data for a tractor of compression ratio 7.8:1. The octane requirement of these high-compression tractors was not satisfied by any commercially available gasoline, but with alcohol-water injection these

TABLE 10. PROPERTIES OF THE FOUR PREMIUM-TYPE LUBRICATING OILS USED IN THE TESTS

Additive type	A Barium-phosphor	B Calcium-zinc	C Phosphorus-sulfur	D Phos-sulfur-zinc
Saybolt universal viscosity at 100 F	498	617	555	552
Neutralization number (ASTM Method D-974-48T)	.05	.20	.06	1.06
Precipitation number (ASTM Method D91-40)	0.00	0.00	0.00	0.00
Conradson carbon (ASTM Method D 180-46	0.65	0.13	0.10	0.22
Ash, sulfated (ASTM Method D 874-46T	0.22	0.08	0.08	0.16
Naphtha insolubles	0.13	0.06	0.12	0.06
Chloroform insolubles	0.24	0.30	0.12	0.55
Asphalt	0.00	0.00	0.00	0.00
Chloroform solubles	0.03	0.02	0.04	0.05

TABLE 11. L-4 TEST RATINGS

	A		B		C		D	
	Std.	With injection	Std.	With injection	Std.	With injection	Std.	With injection
Varnish ratings								
Average piston skirt	9.5	9.7	9.3	9.2	9.5	9.6	9.1	9.2
Cylinder wall	9.5	9.5	9.4	9.3	9.5	9.5	9.2	9.4
Total varnish	48.8	48.7	48.0	47.7	48.5	48.8	47.5	47.9
Sludge ratings								
Total sludge	49.3	48.2	47.7	47.5	48.3	48.7	47.7	47.9
Total rating	98.1	96.9	95.7	95.2	96.8	97.5	95.2	95.8
Bearing weight loss, mg	98.0	91.5	476.5	101.5	364.0	98.0	51.0	39.0
Final neutralization no. (ASTM Method D974-48T)	0.82	0.35	2.17	1.14	2.69	0.71	2.64	1.31

tractors could be operated on a proper grade commercial gasoline. It is of interest to point out here that the alcohol "susceptibility" of gasolines is a function of their composition. This was brought out in a recent paper (**2**) in which it was shown that paraffin and certain aromatic and unsaturated hydrocarbons gave the greatest response to alcohol-water injection, while in some of the commercial gasolines tested, injection was somewhat less effective. In other words, a variation in octane gain with injection will be encountered.

Finally, Fig. 11 gives alcohol-water injection and octane requirement data for a tractor having a compression ratio in the intermediate range, namely, 6.8:1. Here again a slight overinjection takes place at the lower speeds. The graphs certainly emphasize the importance that injectors must be calibrated for each make and model, since engines have their personalities.

Most tractors were used in what presumably can be called average farm operation, though variations were considerable even here. Some "exceptional" cases are of interest since it is here where difficulties might be expected. Table 5 summarizes operational data on a few tractors. It will be noted that Mr. P's tractor received exceptionally hard usage. The engines of these tractors were loaded to the limit in plowing and disking. Probably no tractors would be worked more severely than these. Mr. A's tractor was used only for plowing and disking and this, too, resulted in a high injection rate. Although this injection rate of 11.9 percent equalled that obtained for similar type of work in other cases, it did not represent the "average" rate, since it did not include the lighter types of work encountered in farm work classified as "general" in Table 5. On the other hand, Mr. H seldom used the full power of his tractor, which was designed to pull a 3-bottom, 14-in plow, but was used only with a 2-bottom 14-in plow. This resulted in an injection rate of only 0.94 percent. In other words, a smaller tractor would have handled the loads more efficiently but at an increased average injection rate.

Table 6 is a summary of the field-test data according to the tractor makes and their compression ratios. One interesting factor in the table is the higher than average injection rate for tractor B_1. These tractors had a rated horsepower of 23.7 (Table 3), which is smaller than that of any of the others. With one small tractor on the farm there is a tendency to overload this machine, which was indicated by the higher than average rate of injection. Most of the farmers who used the high-compression engines took advantage of the increased power and used higher gear ratios for obtaining more work per unit of time. Unfor-

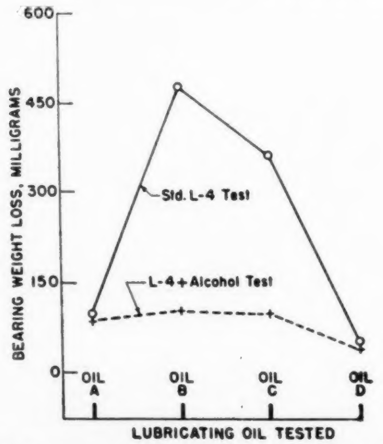


Fig. 12 Bearing weight loss with and without alcohol-water injection for four premium-type oils

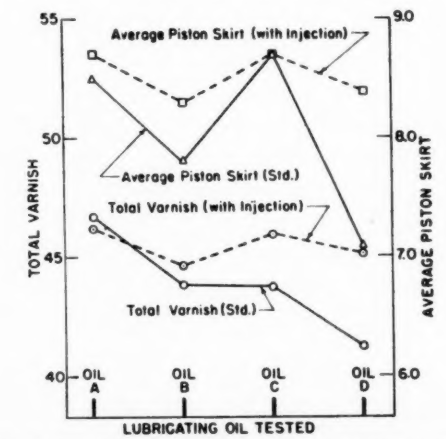


Fig. 13 FL-2 ratings of average piston skirt and total varnish for four premium-type lubricating oils

tunately there was no way of determining the amount of work done by these engines.

Table 7 shows the summary of the field-test data according to the compression ratios. Again there is no positive correlation between the compression ratio and the fuel used per hour. The injection ratios were about the same for all three compression ratio groups.

The most significant results of the field tests are shown by the summation of all the data. The average injection ratios in percent of gasoline used were 1.72 for general work, 6.00 for seedbed preparation, and 3.80 for an average year of operation.

After the test period was over, nine of the tractor engines were completely disassembled and inspected. The combustion chamber deposits were weighed and analyzed and pictures taken of the principal engine components. Representatives of the tractor manufacturers were asked to express their opinions on the engine conditions.

Table 8 shows the analyses of the combustion-chamber deposits, the amount and kind of gasoline used, and the hours of operation of the nine tractor engines which were disassembled. Probably the most interesting case is Mr. H's engine (Table 8) which ran a short time on regular-grade fuel (89 gal) but for the remainder of the time on white gasoline (799 gal). This engine had had 330 hr of operation during the autumn of 1951, after which valves were ground and carbon cleaned. A low-cost non-detergent oil had been used for the entire period with oil and filter change every 100 hr of operation. In this connection, a recent paper entitled "Lubricants — The Surface Savers," **(3)** is of interest. As stated by the authors, "When a fuel of better cleanliness quality was used, however, wear with the straight mineral oil was very much reduced, and the detergent-inhibitor additive now had a much less significant effect on wear." As shown in the following, the white gasoline used by Mr. P was an extraordinarily clean fuel. The performance of the tractor during the heavy spring work was very good, according to the owner. The valve assembly, oil pan, and oil pump were completely free from sludge. The combustion-chamber deposits weighed only 15g. The valves were in excellent shape, and the small identification marks on the valve heads were still legible.

In general, the condition of the engines was not significantly different from that of an engine using gasoline alone for a comparable period of service. There were some indications that the intake manifold and inlet valve stems and seats were cleaner than would be expected for engines not using alcohol-water injection, but the difference in most cases was slight. The combustion-chamber deposits were easily removable. Rings were free and the oil holes in pistons were open.

In a recently published bulletin entitled "Alcohol-Water Injection for Farm Tractors" **(4)**, the practical aspects of injection as applied to farm tractor operation have been discussed in a more elementary fashion.

Effect of Alcohol-Water Injection on Lubricating Oils††

As stated by Georgi **(5)**, "the only satisfactory means of evaluating the performance characteristics of motor oils is by actual use in engines." Two generally accepted and widely used methods are L-4‡‡ and FL-2§§ engine test procedures. The former, designed to stimulate heavy-duty service, evaluates the stability characteristics such as resistance to oxidation, bearing corrosion and prevention of engine deposits, while the latter procedure correlates reasonably well with moderate or light-duty intermittent service on the road (low-temperature operation) and is quite widely used for studying the sludge and varnish-forming tendencies of fuels. An outline of the test conditions is given in Table 9.

The Armour Research Foundation under contract with the Northern Regional Research Laboratory, ran two L-4 and two FL-2 tests on each of four widely used premium-type lubricating oils (Table 10), one run with and the other without alcohol-water injection. In these test procedures varnish, sludge, or carbon are rated numerically from 10 (clear) to 0 (maximum accumulation) by comparison with standards.

L-4 test ratings are summarized in Table 11. Varnish and sludge ratings show little difference with or without alcohol injection; however, bearing-weight loss and neutralization values are significantly less with injection, particularly in two cases. Bearing weight loss with and without injection is shown graphically in Fig. 12.

The outstanding results of the FL-2 tests seem to be in the relative varnish accumulation on the pistons. In all four oils run with the laboratory fuel, the varnish conditions showed definite improvement with alcohol-water injection, either in piston skirt varnish or in total varnish deposits. The sludge conditions seemed to be slightly worse with injection although not detrimentally so. Results are shown graphically in Fig. 13.

CONCLUSIONS

Aberdeen Truck Tests

Alcohol-water injection in combination with a gasoline of 10 octane numbers lower than the engine octane requirement gave knock-free operation in two military type trucks.

This combination of straight-run gasoline with injection resulted in cleaner engines (less sludge, varnish, and combustion chamber deposits) and less cylinder wear than when engines were operated with a prototype gasoline.

Since carburetors were all set at the same flow rate, no fuel economy was realized.

Ohio Agricultural Experiment Station Test

Alcohol-water injection will provide an increase of from 8 to 10 octane numbers in the high commercial octane range and up to about 15 numbers in the distillate and kerosene range. With any given fuel which satisfies the octane requirement, the compression ratio of the engine can be increased when using injection by about 1.5 ratios, up to 8:1 compression. Such an increase will raise maximum power from 10 to 20 percent depending on engine design.

Present tractors and equipment appear to be sufficiently strong mechanically to stand the extra compression ratios. Twenty-five tractors with compression ratios from 6.5:1 to 8:1 were operated for one year without failure.

††The work was carried out at the Armour Research Foundation under the general direction of Wilson Green and direct supervision of Robert W. Olsen.

‡‡CRC Designation L-4-5457, U.S. Army Ordnance Dept. Tentative Specification AXS-155416.

§§CRC Designation FL-2.

The increase in power and smoothness of operation was of more importance to the farmer than the savings in fuel; however, this will depend on general economic conditions, as pointed out by Barger (6).

The only objection raised against the use of injection, and this was very minor, was the extra work of handling the mixture.

To insure trouble-free operation with any injector, the alcohol-water mixture must contain a corrosion inhibitor, since any slight deposit formation is likely to clog the injector passages. It is not recommended that the farmer prepare his own mixtures. With more widespread use of injectors, the alcohol-water mixture should become more generally available commercially.

The selection of the proper injector is important, since the injector must closely reproduce actual injection requirement for best economy and general performance.

Straight-run gasoline in combination with alcohol-water injection results in cleaner engines and consequently longer engine life.

Lubricating Oil Tests

L-4 test results showed that bearing-weight losses and final acidity were significantly less with injection. In all other respects differences were minor.

The alcohol-water mixture was injected continuously in the L-4 and FL-2 tests in order to accentuate any effects of injection on lubrication. Since under practical operation the rate of injection is much less, such beneficial effects as were formed are not likely to be observed under ordinary operating conditions. The tests, however, show that no harmful effects on lubrication are to be expected from injection.

REFERENCES

1 Porter, J. C., Gilbert, M. M., Lykins, H. A., and Wiebe, Richard. Alcohol-Water Injection for High-Compression Tractor and Automobile Engines. AGRICULTURAL ENGINEERING 31 (2) : 71 (1950).

2 Porter, James C. and Wiebe, Richard. Alcohol as an Antiknock Agent in Automotive Engines. *Ind. Eng. Chem.* 44 (5) : 1098 (1952).

3 Kunc, J. F., Jr., and Hamer, J. P. Lubricants — The Surface Savers. SAE Preprint. Presented at the SAE annual meeting, Detroit, Mich., January, 1953.

4 Hummell, John D. and Wiebe, Richard. Alcohol-Water Injection for Farm Tractors. U.S. Dept. Agr. publication AIC-349, processed (1953).

5 Georgi, Carl W. Motor Oils and Engine Lubrication. Reinhold Publishing Corp., New York, chap. IV, p. 66 (1950).

6 Barger, E. L. Tractor Fuels. Engineering Experiment Station, Bulletin No. 37, Kansas State College Bulletin, vol. XXIII (6), May 1, 1939.

New Coffee Scrubber and Washer

R. U. Blasingame and Adolfo Eschenwald
Life Fellow ASAE Affiliate ASAE

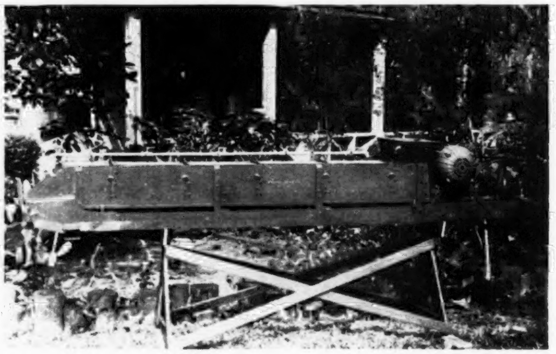
A MACHINE capable of removing the lees (a sticky gelatinous material) from coffee beans has recently been developed and successfully used at Utuado, Puerto Rico. Coffee berries when ripe are first run through a machine that removes the outer covering. The real problem in coffee processing is the removal of the lees from the beans. Up to now this was done by a fermentation process that requires from 6 to 24 hr depending on the climate, the availability of ample water, and man power.

The mechanical principle of the new machine is very simple and efficient. It consists of a compact structure 8 ft long, 16 in wide and 8.5 in deep. The machine is placed in front and just below the peeler. With this arrangement the peeling, scrubbing and washing is done in a continuous operation. The same operator that handles the peeling machine takes care of the scrubbing and washing. This eliminates hand labor and saves time.

A recent study conducted by the authors brought out the following facts:

- The machine is operated with a 2-hp electric motor.
- A model of that size scrubs and washes around 1,200 lb of coffee per hour.
- The machine uses only one-third of the water required by the fermentation process.
- The time-and-labor-consuming fermentation process is eliminated.
- The machine does not use an abrasive.
- The coffee lees, a product rich in pectines, comes out in a pure form which could be used in industry.
- The coffee washed by this machine has a better appearance than the coffee washed by the fermentation method.

The inventor, Heriberto Hess, took the authors to the coffee farm of Pedro Morell where the machine has been used on this year's crop. This is a 400-acre coffee plantation which has been owned and operated by the Morell family for the last 50 years. As a result of studies of actual performance of the machine, the authors believe this new coffee scrubber and washer is going to solve a major problem for all coffee growers.



This picture shows the successful coffee scrubbing and washing machine developed by Heriberto Hess of Puerto Rico. The electric motor is shown at the rear and water spigots at the top of machine

The authors — R. U. BLASINGAME and ADOLFO ESCHENWALD — are, respectively, visiting agricultural engineer, Puerto Rico Agricultural Experiment Station, and associate professor of agricultural engineering, University of Puerto Rico.

Development of a Portable Castor Bean Huller

L. G. Schoenleber and **W. E. Taylor**
Member ASAE   Assoc. Member ASAE

HULLING investigations described in this paper are a continuation of those made by the U.S. Department of Agriculture and Oklahoma Experiment Station, and reported by Porterfield and Oppel* in 1952. A new 18-in huller was built which would lend itself better to research work.

DESIGN OBJECTIVES

The new huller, while retaining the fundamental hulling and cleaning principles embodied in the former machine, is designed to be more compact and lower in silhouette. Further design objectives not found on the older huller are:

1 The inclusion of an integral elevator to convey the beans to the hulling disks at a uniform rate

2 One engine to power all components of the machine

3 A clutch in the power train so that the engine can be started free of load

4 A readily variable fan speed to meet different cleaning requirements

5 Quicker access to the hulling disks to facilitate their rapid change. This was especially desirable for hulling research work

6 A more accurate method of adjusting the space between the hulling disks

7 More precise construction and machining of the hulling disks to eliminate disk wobble and warpage, thereby insuring a more uniform disk spacing at all points between the disks

8 A machine with adjustments to permit a greater range for tests and conditions for research investigations.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors—L. G. SCHOENLEBER and W. E. TAYLOR—are, respectively, senior agricultural engineer, farm machinery section, agricultural engineering research branch, U.S. Department of Agriculture and agricultural engineer, Oklahoma Agricultural Experiment Station.

*AGRICULTURAL ENGINEERING, vol. 33, pp. 713-716, November, 1952.

DESCRIPTION OF HULLER

1 *Hulling Unit.* There are five major components in the 1952 huller, the principal one being the two rubber-covered steel disks between which the beans are hulled. These disks are mounted horizontally, parallel, and axially coincident. Both steel disks have an outside diameter of 18 in and are $^{5}/_{16}$ in thick. The lower disk is bolted to an 11-in-diam flat hub which is welded to a $1\frac{1}{2}$-in vertical shaft. This vertical shaft is supported by two pillow-block bearings and a thrust bearing and is rotated by V belt and sheave at its lower end. By means of a hand wheel and screw arrangement, the entire assembly of sheave, shaft, bearings, hub, and lower disk can be raised or lowered by small increments to adjust the spacing between the disks. To insure having a plane surface on the lower disk, it was machined flat while bolted on the shaft and hub assembly. Mounting holes in the disk and hub are indexed so that the disk can be remounted after any removal in the same relative position to prevent wobble.

The upper disk has an 11-in inside diameter hole with four equally spaced studs mounted on a $14\frac{1}{2}$-in-diam on one face of the disk. These studs extend through the top plate of the hulling assembly and can be adjusted vertically by means of a threaded sleeve and lock nut arrangement. This feature provides for adjustment of space between the plates. The working surface of the upper plate is ground flat.

The adjacent surfaces of the two disks are faced with abrasion-resistant rubber, the rubbers being bonded to the steel disks with rubber cement. The thickness, hardness, size, and shape of these rubbers were varied during the various tests. To eliminate the time-consuming job of recementing the rubbers each time for test purposes, a disk was made up for each rubber. Then to change the rubbers required only to remove eight nuts or screws and change the entire disk and rubber assemblies. A schematic design of the huller is shown in Fig. 1. A picture of the machine under test is shown in Fig. 2.

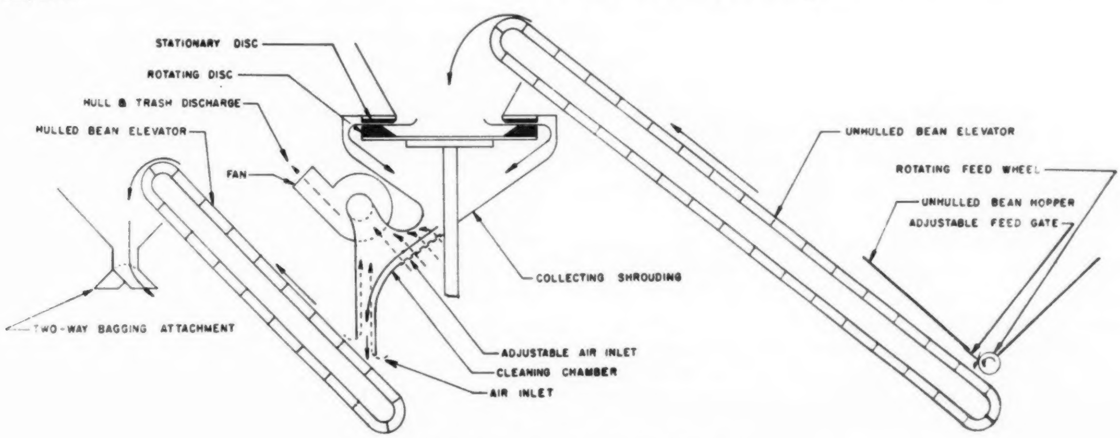


Fig. 1 Schematic diagram of castor bean huller

2 *Cleaner.* The horizontal hulling disks are surrounded by a sheet-metal shrouding to collect and direct the mixture of hulls and beans to the cleaning chamber. This chamber is a vertical air duct of 3 x 20-in rectangular cross section. The upper end of this duct leads to the intake of an 18-in centrifugal fan. The lower end is open to admit air to the fan; thus the movement of air in the duct is upward. The beans and hulls slide down the bottom of the collecting shrouding at an angle of 35 deg from horizontal. They enter the upward moving column of air near the upper end of the rectangular cleaning duct. Hulls, trash, dirt, and some light beans are borne upward and into the fan by the airstream while the sound beans fall through and out of the vertical cleaning duct. An adjustable vent in the bottom of the collecting shrouding, over which the beans and hulls must pass, bleeds air and consequently hulls into the vertical column of air. Observation shows that a considerable amount of the hulls are separated from the sound beans in the "upward moving column of air." The hulls, trash, and light beans are discharged from the fan through an 8-in pipe.

3 *Hulled-Bean Elevator.* The low silhouette of the machine was achieved mainly by use of elevators for conveying the beans both into and away from the huller. The hulling disks are at an elevation of approximately 4½ ft from the ground, and the beans fall approximately 3½ ft before their exit from the cleaner. Consequently an elevator was necessary to raise them back up to bagging height. This elevator is constructed of heavy canvas and wooden flights spaced approximately 10 in apart. The elevator is 14 in wide and the flights are 2 in at the maximum in depth. The lower end of the elevator is under the discharge end of the cleaning chamber to receive the hulled beans, and the upper end discharges into a bagging arrangement similar to that used on some combines. The elevator and bagging assembly is easily removable for transporting the huller.

4 *Unhulled-Bean Elevator.* Due to the 4½-ft elevation of the hulling disks, it would be inconvenient to scoop unhulled beans from a truck or wagon into a hopper mounted over the disks. To facilitate unloading of wagons and trucks, a hopper was constructed near the front of the machine. The top of this hopper is 30 in from the ground and its capacity is about 3 bu.

In the bottom of this hopper a rubber-covered roll rotates slowly to uniformly feed the unhulled beans into an elevator. This elevator is similar to that for the hulled beans into an elevator. The upper end of the elevator discharges into a small hopper over the hulling disks. The beans feed from this hopper through an 11-in inside diameter opening in the upper disk, onto the rotating disk, and thence radially outward between the rubber faces of the two disks.

5 *Power Source.* An 8¼-hp gasoline engine is mounted on the frame of the huller and belted to a longitudinal countershaft. A hand-operated idler of the V belt connecting the engine and countershaft serves as an engine clutch. V belt drives are used to transmit power from the countershaft to the hulling disks, hulled-bean elevator and centrifugal fan. A variable-ratio, V-belt transmission is connected between the fan and countershaft to permit rapid adjustment of fan speed.

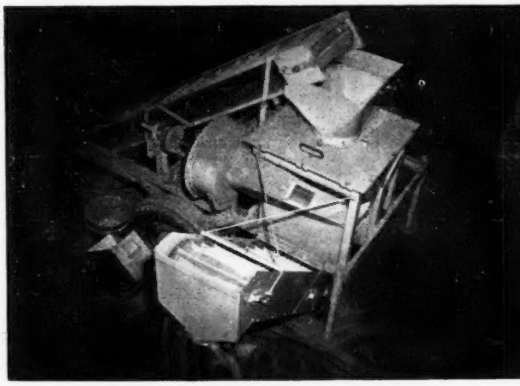


Fig. 2 Castor bean huller under test

One of the objectives in the design of this huller was to power all components with one engine. However, for research on the machine it was considered advantageous to drive the unhulled-bean elevator with a ¾-hp electric motor and variable-speed hydraulic transmission in order to have more accurate control of the rate of feeding. Furthermore, the speed of the hulling disk can be changed only by the throttle setting of the gasoline engine. To facilitate disk speed change and determination of power requirements, a 5-hp electric motor with a variable-speed pulley unit is used to power the huller during tests. The gasoline engine is provided for all hulling not of a research nature.

6 *General.* The huller frame and most of the components are of welded-steel construction. The machine is readily made portable by the removal of the hulled-bean elevator and raising of the unhulled-bean elevator to transport position. This takes only a few minutes to set up for hulling or disassemble for transporting. The huller is built in the form of a two-wheel trailer using two 6.00 x 16 tires bearing the weight during transport. In operating position, two retractable supports stabilize and help support the rear end of the machine. Over-all weight of the machine is 1550 lb. Length in transport position is 11½ ft, width 59 in, and height 75 in.

HULLING MATERIAL AND TEST PROCEDURE

The new huller was used to investigate the effects of disk speed, disk rubber thickness, effective area of disk rubber, shape of entrance between rubbers, size of rubbers, and force-feeding the beans between the rubbers on hulling rate and quality of hulling. Also, the effect of these variables on power requirements was investigated.

Approximately 28,000 lb of Cimarron beans were used for the tests. These beans were all grown in one 38-acre field at Altus, Okla., and were considered of sufficient uniformity for test purposes. The beans were all harvested by one USDA harvester. Little trash remained with the harvested beans, which consisted mainly of leaf petioles and fine dust from handling the beans after harvest.

The castor beans were killed by frost while they were still growing vigorously, which resulted in approximately 24 percent of unfilled beans (pops). This affected hulling capacity considerably, as a larger bulk of material passed through the machine than normally required for the same amount of sound beans received.

The following criteria for quality of hulling were used for the majority of the tests:

1 The combined cracked, broken, and unhulled beans were not to exceed 2 percent of the hulled beans.

2 The amount of oil-bearing material blown in with the hulls was not to exceed 1 percent of the total weight of oil-bearing material passing through the machine.

3 The foreign material in the hulled beans was not to exceed 10 percent. Since a large percentage of the beans tested were pops (24 percent), it was virtually impossible to remove all of them in the huller cleaner without blowing some sound beans out with the hulls. For this reason, the rather large figure of 10 percent foreign material was tolerated. Of this 10 percent foreign material, 90 to 95 percent consisted of pops; the remaining 5 to 10 percent was made up of hulls, sticks, and miscellaneous trash. Had the beans used been 100 percent sound, the foreign material would have been 0.5 to 1 percent.

Accessory equipment used during the testing consisted of an integrating wattmeter for measuring the electrical power consumption, a laboratory balance calibrated in grams, a small pair of platform scales calibrated in pounds and ounces, and a small Clipper seed cleaner for removing foreign material from the test samples.

The testing procedure used for each of the different disk treatments was as follows:

1 Adjust spacing between the disks to produce the lowest total percentage of broken and unhulled beans.

2 Adjust head of beans in hopper over hulling disks for maximum hulling rate

3 Adjust cleaner fan speed for optimum cleaning effectiveness. Spot checks were made to determine percent of oil-bearing material being blown in with hulls

4 Catch and record time required to hull three 50-lb (approx.) samples of hulled beans

5 Weigh samples and compute hulling rate

6 Take three 400-g samples from each 50-lb sample and determine on a weight basis the percentages of broken beans, unhulled beans, and foreign material in the hulled beans. All material blown out of the 400-g samples by the Clipper cleaner was considered foreign material. The broken and unhulled beans were picked out of the sample by hand

7 Record electrical power used both during hulling and while machine is running empty.

DESCRIPTION OF TESTS

1 *Rubber Thickness Test.* One test made with the huller was to determine the effect of disk rubber thickness on the hulling rate and quality of work done by the machine. In this test, four rubbers of different thicknesses were used on both the upper and lower disks — a total of eight rubbers. The upper rubbers ranged from 52 to 54 durometer points in hardness, and the lower rubbers from 31 to 35 durometer. The rubber thicknesses were ¼, ½, ¾, and 1 in. All of the sixteen possible combinations were tested with the experiment set up to analyze the results statistically. The upper rubbers were 18-in outside diameter and 11-in inside diameter with the inside diameter being beveled outward at 45 deg. The lower rubbers had the same dimensions, but were beveled outward from the inside diameter to a diameter of 14-in leaving a flat hulling surface 2 in wide with an area of 100 sq in. Thus each thickness of upper rubber had a different width of hulling surface, and each thickness of lower rubber had a different angle of bevel.

In this test, the disk speed was held constant at 550 rpm ($\pm$10 rpm). The fan speed was 1100 rpm ($\pm$20 rpm). Preliminary tests had shown that this fan speed produced the maximum cleaning efficiency over a wide range of conditions.

2 *Rubber Hardness Test.* In the above test it is noted that four thicknesses of rubbers in each of two hardnesses (32 and 52 durometer approximately) were used. Even though Porterfield and Oppel investigated the effects of rubber hardness in their work, the availability of these two sets of rubbers suggested that further data might be obtained along that line. In this test all thicknesses in each of the two hardnesses (32 and 52) were used on the upper disk, while the lower rubber was constant at 1-in thickness and 35 durometer hardness. The disk speed in this test was 550 rpm and fan speed was 1100 rpm.

3 *Disk Speed Test.* Another test consisted of determining the effect of disk speed on hulling rate and quality. In this test, the two rubbers forming the best combination in the thickness test, ¼ in by 52 durometer upper and 1 in by 35 durometer lower, were used. The speed of the disk was varied from 350 to 800 rpm in increments of 50. The fan speed was varied from 1100 to 1300 rpm in order to give the maximum cleaning efficiency over the entire range of disk speeds.

4 *Width of Hulling Surface Test.* To determine the effect of the width of the rubber hulling surface, new rubbers with 18-in outside diameter and 7-in inside diameter were installed on the machine. The upper rubber was ¼ in thick and 38 durometer in hardness. Its inside diameter was beveled outward at 45 deg. The lower rubber was 1 in thick and 70 durometer. It was beveled outward from the 7-in inside diameter to a 10-in diameter. Thus a hulling surface 4 in wide with a area of 176 sq in was present on the disk as compared to a 2-in surface with an area of 100 sq in on the standard rubbers. Since the hardness of these two rubbers was different from any of the other rubbers tested, a control or standard set of rubbers was made from the 38 and 70 durometer material. Standard is used here to mean the 18-in outside diameter by 11-in inside diameter rubbers beveled outward at 34 deg to a 14-in diameter. Each of these two sets of rubbers was run at 550 and 700 rpm. The fan speed was constant at 1100 rpm.

5 *Angle of Bevel Test.* In order to investigate the effects of the angle at which the lower rubber was beveled, the same two sets of rubbers were used as in the hulling surface width test. However, for this test the lower rubber was beveled outward from the 7-in inside diameter to the usual 14-in diameter. Thus the angle of bevel was 16 deg

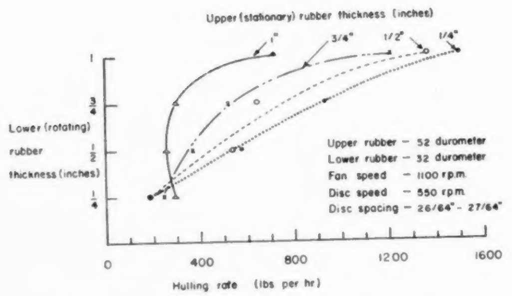


Fig. 3 Effect of rubber thickness on hulling rate

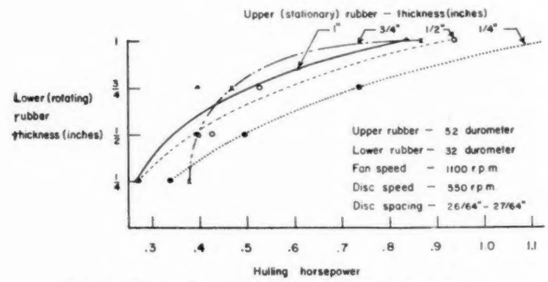


Fig. 4 Effect of rubber thickness on hulling power

from horizontal as compared to 34 deg on the 1-in rubbers with 11-in inside diameter. This set of rubbers was then compared with the control or standard set at 550 and 700 rpm.

6 *Force-Feeding.* Various informal tests were made to determine the maximum possible hulling rate of the 18-in machine. Spiral flutes similar to the involute impellers of a centrifugal water pump were developed and fastened to the center portion of the rotating disk in an attempt to force-feed the beans between the rubbers at a higher rate. With the 18-in outside diameter by 11-in inside diameter rubbers on the disks, this force-feeding mechanism was tested at various disk speeds between 515 and 800 rpm and fan speeds of 1100 to 1400 rpm. The upper rubber was ¼ in thick and 52 durometer in hardness, while the lower was 1 in thick and 35 durometer.

7 *12-in Diameter Rubbers.* A set of rubbers of 12-in outside diameter and 5-in inside diameter was then installed on the hulling disks and tested for hulling rate and quality of work. The upper rubber was ¼ in thick and 38 durometer while the lower rubber was 1 in thick and 33 durometer. The inside diameter of the upper rubber was beveled at 45 deg; that of the lower was beveled outward to a 7-in diameter, leaving a 2½-in hulling surface having an area of 74.6 sq in. A small impeller was attached to the center portion of the rotating disk. The disk speed was 100-rpm (the approximate limits of the machine design) and the fan speed and 1100 rpm.

PERFORMANCE AND RESULTS OF TESTS

1 *Rubber Thickness Test.* Data obtained in this test indicate that within the range of the rubber thickness tested, the hulling rate is proportional to the thickness of the lower (rotating) rubber and inversely proportional to the thickness of upper (stationary) rubber. The hulling rate (Fig. 3) varied from 192 lb per hr with a ¼-in lower and 1-in upper rubber to 1520 lb per hr with a 1-in lower and ¼-in upper rubber. However, as pointed out in the description of the rubber thickness test, the width of the hulling surface on the upper rubbers and the angle of bevel for the lower rubbers were different for each rubber thickness. These variations might well have had some effect on the hulling rate; however, no analysis of this possibility can be made from the data presently available.

No relationship was discernible between rubber thickness and quality of work, quality being used here to mean the percentages of broken beans, unhulled beans, and foreign material present in the hulled beans. Curves drawn

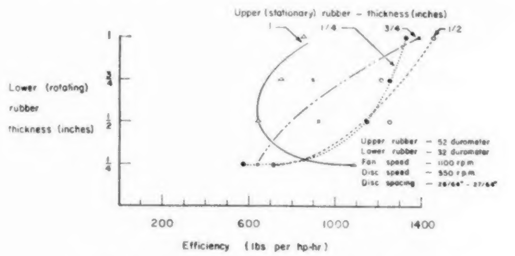


Fig. 5 Effect of rubber thickness on efficiency

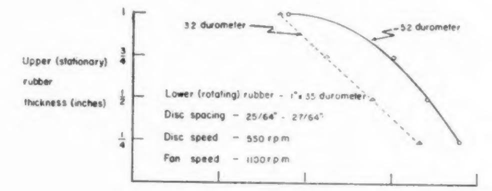


Fig. 6 Effect of upper rubber hardness on hulling rate

to show the relation between rubber thickness and quality were very erratic. The percent of broken and unhulled beans and percent of foreign material were well below their respective standards of 2 percent and 10 percent.

In these tests, hulling horsepower is the difference between total horsepower and tare horsepower. Tare horsepower is that required to run the disk, fan, and hulled-bean elevator at operating speed with no beans being fed into the machine. Then hulling horsepower is the net power required to actually hull, clean, and elevate the beans.

From the curves in Fig. 4 it is seen that the hulling power requirements are also proportional to the lower rubber thickness and inversely proportional to the upper rubber thickness. This is, at least to some degree, a direct function of the hulling rate rather than the rubber thickness. Hulling horsepower requirements varied from 0.27 hp for the ¼-in lower and 1-in upper rubbers to 1.14 hp for the 1-in lower and ¼-in upper rubbers. The latter rubber combination required the greatest total horsepower (3.16). Tare horsepower for almost all of the tests ranged from 1.6 to 2.5.

The efficiency with which the hulling horsepower is used is a more logical evaluation of the rubber thickness than is the power requirement. From the curves in Fig. 5 it is seen that, in general, an increase in lower rubber

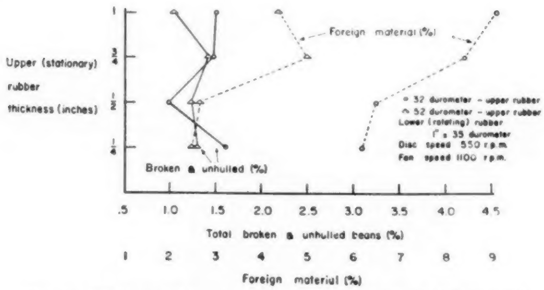


Fig. 7 Effect of rubber hardness and thickness on broken and unhulled beans and foreign material

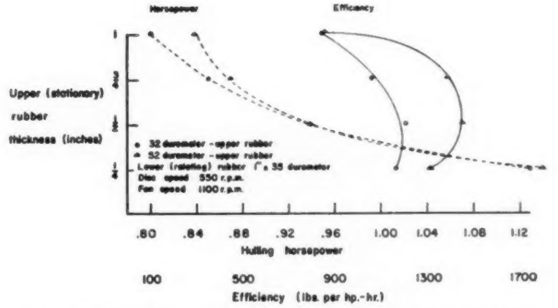


Fig. 8 Effect of upper rubber hardness on power requirements and efficiency

thickness produces an increase in the efficiency (pounds of beans hulled per hour per hulling horsepower). It is not apparent that upper rubber thickness has a definite effect on efficiency.

2 *Rubber Hardness Test.* In this test it was found that, for both the 32 and 52 durometer upper rubbers, the hulling rate was again inversly proportional to the thickness of the upper rubber, and that a higher hulling rate was obtained with all thicknesses of the 52 durometer upper rubbers than with those of the 32 durometer (Fig. 6).

No definite relation between hardness and the presence of broken and unhulled beans was noted but about twice as much foreign material was left in the hulled beans when using the 32 durometer rubbers as when using the 52 durometer (Fig. 7).

Hulling power requirements were practically the same for both hardnesses, but the efficiency (lb per hp-hr) was greater for all thicknesses of the 52 durometer rubber than for those of the 32 durometer (Fig. 8).

3 *Disk Speed Test.* The hulling rate was found to be almost directly proportional to the disk speed. The rate varied from 701 lb per hr at 350 rpm to 3107 lb per hr at 800 rpm (Fig. 9). The amount of broken beans ranged from 0.26 percent at the lower disk speeds to 2.16 percent at the higher disk speeds. The amount of broken beans increased only slightly for slow disk speeds, but increased rapidly at the higher disk speeds. The amount of unhulled beans was smallest (0.72 percent) for disk speeds between 500 and 700 rpm. Above and below this range of disk speeds, the percentages increased. A few more hulls were observed in the hulled beans at the higher hulling rates than at the lower ones; but since these few hulls had little weight, they did not increase the foreign material weight percentages measurably. Foreign material varied from 1.66 to 6 percent.

The hulling power requirements were found to be proportional to the disk speed (Fig. 10), but again this is probably a function of the hulling rate. Hulling horsepower varied from 0.45 hp at 350 rpm to 3.16 hp at 800 rpm.

Statistical analyses using the method of least squares were made on the data to determine which of the straight line, quadratic, or cubic equations expressed the data best. The equations for this data as shown in Figures 9 and 10 were found to be as follows:

$$y_1 = \text{tare horsepower} = 1.11 + \frac{14.38X}{10^4}$$

$$y_2 = \text{hulling horsepower} = 1.06 + \frac{52.14X}{10^4} + \frac{9.88X^2}{10^6}$$

$$y_3 = \text{total horsepower} = 3.01 - \frac{69.04X}{10^4} + \frac{1.26X^2}{10^5}$$

$$y_4 = \text{unhulled beans (percent)} = -3.76 + \frac{4.6X}{10^2} - \frac{1.12X^2}{10^4} + \frac{8X^3}{10^8}$$

$$y_5 = \text{broken beans (percent)} = 1.92 - \frac{83.16X}{10^4} + \frac{10.88X^2}{10^6}$$

$$Z = \text{rate of hulling (lb per hr)} = 327.96 - \frac{51X}{10^2} + \frac{48X^2}{10^4}$$

X = disk speed in rpm.

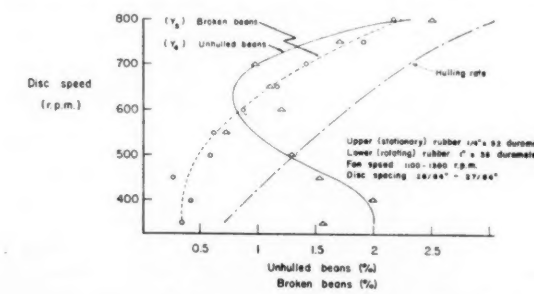


Fig. 9 Effect of disk speed on broken, unhulled beans, and hulling rate

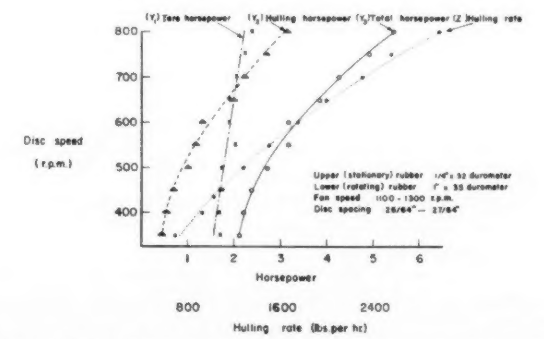


Fig. 10 Effect of disk speed on hulling rate and power requirements

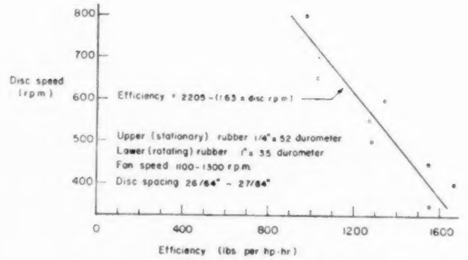


Fig. 11 Effect of disk speed on efficiency

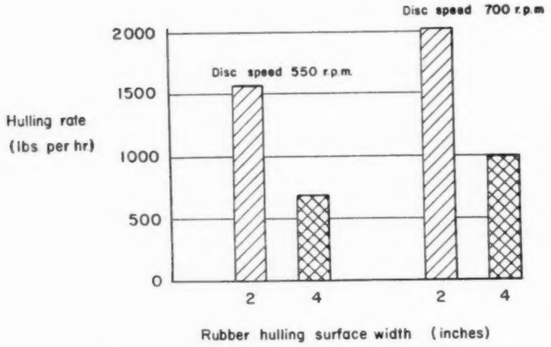


Fig. 12 Effect of rubber hulling surface width on hulling rate

Fig. 11 shows that an increase in disk speed from 350 to 800 rpm produces a decrease in efficiency from about 1650 to 900 lb. per hp-hr. The regression between efficiency and disk speed can be expressed as follows: efficiency = 2205 - 1.63 x disk speed, where disk speed is in revolutions per minute and efficiency is in pounds per horsepower-hour.

4 *Width of Hulling Surface Test.* In this test it was found that the narrow hulling surface (2 in wide, 100 sq. in) hulled beans 2.06 times as fast as the wide surface (4 in wide, 176 sq in) at 550 rpm. At 700 rpm the narrow surface hulled beans 2.34 times as fast as the wide surface. At the same time the efficiency (pounds per horsepower-hour) was 22 percent greater for the narrow surface than for the wide surface at 550 rpm and 46 percent greater at 700 rpm (Fig. 12).

5 *Angle of Bevel Test.* In this test, the rotating rubber with the small angle of bevel (16 deg) hulled beans 10.7 percent faster at 550 rpm and 14 percent slower at 770 rpm than did the rubber with the 34-deg bevel. The efficiency was slightly greater at both disk speeds for the 16-deg bevel rubber.

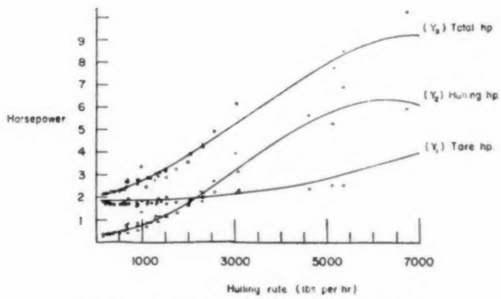


Fig. 13 Effect of hulling rate on horsepower

6 *Force Feeding.* With other conditions being the same as in the disk-speed test previously discussed, the effect of adding spiral impellers to the rotating disk was an increase in hulling rate of 60 to 175 percent. The maximum rate was 6750 lb per hr at 710 rpm disk speed. An even higher rate could probably have been attained if sufficient power had been available. The quality of work at these higher rates was somewhat lower, the unhulled beans being of the order of 4 to 5 percent, and broken beans 1 to 2 percent.

The higher hulling rates produced by the addition of the spiral impellers required correspondingly higher hulling horsepower. The maximum required was 5.96 hp at 6750 lb per hr. The tare horsepower at that rate was 4.34 and total horsepower 10.3. No effect on efficiency (pounds per horsepower-hour) by the addition of impellers was discerned.

7 *12-in-Diameter Rubbers.* These rubbers were capable of hulling at a rate of 716 lb per hr at a disk speed of 1000 rpm. Higher disk speeds were not possible because of unbalance of the rotating disk and other moving parts. At this speed and rate the total of broken and unhulled beans was 1.62 percent.

8 *Power Requirements.* The total horsepower is the combined power to rotate the machine at full speed with no beans going through (tare horsepower) plus the power required to actually hull the beans. The total power requirements for hulling castor beans increased in proportion to the hulling rate. The total horsepower requirements varied from 2.1 hp when hulling at the rate of 290 lb per hr to 10.2 hp at 6750 lb per hr. The hulling horsepower ranged from 0.2 hp for the low hulling rate to 6.9 hp for the high hulling rate. The tare horsepower ranged from 1.8 hp at the low hulling rate to 4.3 hp at the high hulling rate (Fig. 13).

(Continued on page 336)

General effects of	*On rate*	*On quality*	*On efficiency*
1 Increasing upper rubber thickness	decreases	none apparent	not definite
2 Increasing lower rubber thickness	increases	none apparent	increases
3 Increasing hardness differential between lower and upper rubber (from 0 to 20 points)	increases	decreased foreign material percent	increases
4 Increase disk speed	increases	increases to 450 rpm., decreases above 550 rpm	decreases
5 Increasing width (area) of hulling surface	decreases	none apparent	decreases
6 Increasing angle of bevel on lower rubber (from 16 to 34 deg)	none apparent	none apparent	decreases
7 Adding impellers to rotating disk	increases	decreases	non apparent

Agricultural Processing Engineering

S. M. Henderson

IT IS the purpose of this paper to define the field of agricultural processing engineering, to discuss some of its characteristics, and to estimate its future possibilities.

Some time after the formal organization of the American Society of Agricultural Engineers in 1907 the interests, work and training of ASAE members were found to be of such a nature that four professional divisions evolved. Members identified with the Soil and Water Division are interested in soil and water conservation, reclamation, drainage and irrigation. Their specialized training is in civil engineering, soil science, fluid mechanics, and meteorology. Those members identified with the Power and Machinery Division have been instrumental in developing the machinery and specialized matched power units which permit the farm worker to produce a maximum of work with a minimum of labor. Training for this work is somewhat parallel to that for mechanical engineering. Members allied with the Farm Structures Division activity have developed homes specially designed for the farmer and his family, barns, and animal and storage structures which are more functional and efficient. They have helped with the development of appropriate building techniques and materials for agriculture The agricultural engineer interested in buildings has special training in architectural and civil engineering. Members active in the Rural Electric Division have been instrumental in providing the farming population with electrical energy and many of the conveniences and devices which are possible only because of the availability of this type of energy. Special training in electrical engineering is usually taken.

The results of the efforts of agricultural engineers can be shown in a variety of ways. A significant observation can be made from data in the Census and the Yearbook of Agriculture (Fig. 1). The total population of the United States increased 63 percent between 1910 and 1950. The farm population *decreased* 24 percent during the same period. The amount of land being farmed increased 32 percent and the acres handled per farm worker jumped from 72 to 111. In 1934, 11 percent of our farms had central station electric service. The percentage had climbed to 84 percent by 1951. The ability of a decreasing farm population to supply an increasing total population with most of its required agricultural products and to have a surplus of many of these products would not have been possible without many significant contributions by agricultural engineers.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, as a contribution of the Farm Structures and Rural Electric Divisions.

The author—S. M. HENDERSON—is associate professor of agricultural engineering, University of California (Davis).

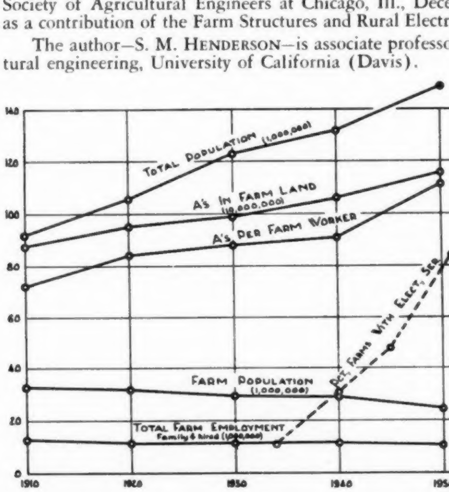


Fig. 1 Population trends since 1910. Agricultural engineering has helped a decreasing farm population supply the food for an increasing total population

A score or more years ago agricultural engineers were introduced to problems dealing with animal feed preparation, cotton ginning, hay drying, milk handling, and farm refrigeration. These and other problems related to fruit and vegetable packing, drying, freezing, and canning, grain and seed drying and storage, the milling of fiber crops, oil crop processing, egg grading and quality maintenance have had the attention of agricultural engineers since that time. Although the training and experience of those within the professional divisions of the Society has not fitted them specifically to handle this type of problem, the problems were attacked and accepted solutions resulted.

About 10 years ago the term "processing" began to appear in AGRICULTURAL ENGINEERING. C. J. Hurd's paper entitled "Rural Industry—A Challenge for Agricultural Engineers" (AGRICULTURAL ENGINEERING, February, 1945) cited the benefits which result when the farm products are processed in rural communities. The late Paul W. Chapman challenged agricultural engineering in his paper "Some Engineering Implications in Agricultural Industries and Services" (AGRICULTURAL ENGINEERING, August, 1946) wherein he also pointed out, among other things, the benefits of local processing plants. An editorial in AGRICULTURAL ENGINEERING in March, 1949, titled "Rural Processing," implied the existence of a finite engineering area which is different from the other areas (divisions) of the Society. An ASAE Committee on Agricultural Processing organized in 1949 published a definition and description of agricultural processing (AGRICULTURAL ENGINEERING, June, 1950). W. M. Hurst discussed the history and work of the USDA Division of Mechanical Processing and set out many of the problems existing in the area in an article entitled "Industrial Applications of Agricultural Engineering" (AGRICULTURAL ENGINEERING, September, 1950), and the same issue carried two editorials entitled "Rural Industries" and "Progress in Farm Processing." This subject was given additional editorial treatment in the August, 1952, issue under the title "Sound Promotion of Farm Processing" and in the September issue the same year under "Economics of Farm Processing."

A summary of these articles would show that engineers and others are aware of the benefits which could result under an active processing program. The summary would also cite examples of processing activities which have proved beneficial to the individual farmer and the community. Also indicated was a state of uncertainty and some confusion as to the method which should be followed in developing this area. I would like to attempt, therefore, to crystallize some

of the features of this area and perhaps to assist in pointing out the direction its development should take. First, a definition of the area:

The Processing Area

Webster defines *process* as follows: "To subject (especially raw materials) to a process of manufacture, development, preparation for market, etc.: to convert into marketable form, as livestock by slaughtering, milk by pasteurizing, grain by milling, cotton by spinning, fruits and vegetables by sorting and repacking . . ." In the light of this definition and the current processing activity within the American Society of Agricultural Engineering, agricultural processing can be defined as any processing activity which is or can be done on the farm or by local enterprises in which the farmer has an active or closely related interest. More specifically, any farm or local activity which maintains or raises the quality or changes the form or characteristics (including economic) of a farm product may be considered as "processing."

Following are some activities which could be listed as agricultural processing:

- Cleaning, sorting, grading, treating seed, grain, peanuts, cotton, nuts, fruits, vegetables, eggs
- Drying, dehydrating, or curing seed, grain, nuts, cotton, forage, tobacco, hops, fruit, vegetables, milk, eggs
- Grinding and mixing animal feeds, fertilizers
- Milling rice, fiber crops
- Canning fruits and vegetables
- Dressing meat and poultry
- Conditioned storage and transportation of products
- Freezing meat, vegetables, fruits
- Other processing involving such products as butter, cheese, ice cream, fluid milk, honey, sorghum, molasses, turpentine, mint.

It will be noted that all of the foregoing kinds of processing are practiced to do one or more of the following:

- Provide a higher net yield from a raw farm product by increasing the quantity of the finished product or products
- Increase the net return by raising the quality of the finished products
- Produce a greater variety of marketable products from a single raw product
- Increase the net return by maintaining quality for a sufficient time to utilize better markets.

A single processing job usually involves more than one of these activity objectives.

It is sometimes difficult to determine whether a specific job is agricultural processing or industrial processing. A large vegetable canning operation such as conducted by one of the national canned food corporations would probably be recognized as industrial processing. A comparable smaller process in a small community would probably be agricultural processing. The point at which the process would move from one classification to the other would be difficult to fix although in the final analysis the portion of the definition—". . . in which the farmer has an active or closely related interest"—usually permits a clear classification to be made.

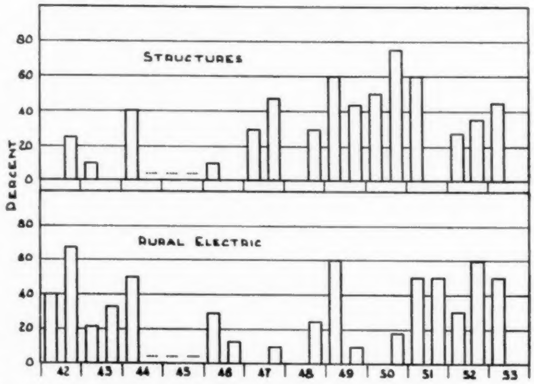


Fig. 2 Portions of the subject matter of the farm structures and rural electric programs of ASAE annual and winter meetings, for the period 1942-53 which could be classed as processing

Current Agricultural Processing

The importance of agricultural processing as previously defined can be evaluated in a number of ways.

In 1926, the U.S. Department of Agriculture started work on a cotton seed drier at Tallulah, La. In 1931, a cotton-ginning laboratory was established at Stoneville, Miss. Sixteen years after starting work on the cotton seed drier, the USDA Division of Mechanical Processing came into formal being. This division has been active in studies of poultry dressing plants, produce markets, feed manufacture, dairy products manufacture, fertilizer manufacture, fence post treatment, equipment and procedures for small rural cold storage and canning plants, fruit packing plants and cotton ginning. The USDA Farm Structures Division is spending more effort on grain drying than on any other single subject. The USDA Farm Electrification Division is working on hay drying, moisture determination, and egg grading. For the 1952-53 fiscal year, the USDA agricultural engineering research budget was distributed thus: 28 percent was allocated to mechanical processing; 24 percent went to structures with 41 percent of the projects being processing. Sixteen percent was used by rural electrification with 54 percent of the projects being processing. The balance, 32 percent, went to power and machinery. Forty-eight of the 102 live projects or 47 percent of the entire USDA research program was processing.

A study of the ASAE winter and annual meeting programs shows that during the last 12 years 26.6 percent of the meeting subjects on farm structures program could be listed as processing, while 28.4 percent of the subjects on rural electric programs were processing. The percentages for the individual years are reported in Fig. 2. This graph shows the relative importance of processing when compared with other subjects naturally included in the farm structures and rural electric programs.

Three years ago the ASAE Committee on Processing was established. During the year which ended last July first, all of the state colleges, including Canada, Hawaii and Nova Scotia, were surveyed regarding engineering teaching and research in processing. Some of the results based on 30 reports are:

- Twenty percent of the research budgets was used for processing research (federally supported research is

included). California, Georgia, Massachusetts, Texas, and Vermont indicated that 40 percent or more of their research funds were used for processing.

- The number of staff members spending more than one-third of their research time on processing averaged 1.5 for the 30 reports. California had 7, Georgia 5, Indiana 5, Louisiana 5.
- Five states are offering courses in processing to professional agricultural engineering students. Certain other states include processing subjects in other courses or are contemplating establishing courses especially for processing instruction. Eight states teach engineering service courses to students in food science and related fields. Three states reported a need for service courses of this type in their curriculum.
- Research activities and needs were indicated in all of the agricultural processing areas. Special need for research dealing with materials handling and feed preparation was indicated.

Unfortunately, available agricultural statistics are insufficient to show the material and economic benefits that have resulted from individual agricultural processing engineering activities. Although it does not seem advisable to take time (and space) to list the many publications on this subject that have been and are helping solve the problems in this area, note of certain contributions can be made. The development of small rural processing plants in Georgia; labor-saving procedures from Indiana, Vermont, and other states; improved apple storage practices from New York and Washington; hop drying from Oregon; fruit grading from Michigan; fruit and nut drying from California are examples of the many processing procedures which have been developed or improved during the last few years. The extensive contributions to the art and science of forage and grain drying and dairy products processing both rurally and industrially by many researchers is further evidence of the contributions in the processing area.

Training in Agricultural Processing Engineering

Agricultural processing engineering can be observed as somewhat similar to industrial engineering since plant layout and management and work simplification are important considerations. It is likewise somewhat similar to chemical engineering because of the extensive use of heat-transfer operations, materials handling, drying principles and others, but specifically because the "unit operation" concept of chemical engineering can be applied effectively to agricultural processing engineering jobs.

An agricultural processing job can be broken down into a series of specific events or "unit operations." Many of these events or unit operations are common to more than one process. For example, size reduction is used in feed preparation, vegetable canning, hay dehydration. Refrigeration is used in milk, fruit, meat, and poultry processing. Heat transfer is important to refrigeration, drying, cooking, evaporating processes. Others such as cleaning and sorting, air conditioning, etc., could be listed with examples.

During the last six years I have been teaching and doing research in agricultural processing. During this period I have helped in preparing the manuscript for an engineering textbook on agricultural processing and served as chairman of the ASAE Committee on Processing. These diversified activities have pointed out that the agricultural processing engineer needs certain training over and above that normally received in the undergraduate agricultural engineering curriculum. The following subjects seem to be of unique importance and are recommended for detailed study by the student interested in the processing area:

Size reduction	Steam generation and use
Cleaning and sorting	Drying and dehydration
Mixing	Concentration by evaporation
Materials handling	Pumps and fans
Heat transfer	Plant layout
Air conditioning	Work simplification
Refrigeration	Instrumentation

Note that ability in these subjects, which might be loosely called "unit operations," fit an engineer to solve most of the problems in processing engineering. Size reduction, cleaning and sorting, mixing, materials handling, pumps and fans, steam production and use, and instrumentation are not peculiar to processing. They are used in other areas of agricultural activity and receive some consideration in the conventional training program. However, a more extensive treatment of them is needed by the student who will be called upon to solve problems in the processing area. The remaining subjects are of unique importance to processing. They are seldom studied extensively by the agricultural engineer. Appropriate laboratory exercises should be used to compliment the formal classroom presentation. The usual basic courses in engineering, particularly those in fluid mechanics and thermodynamics, are assumed as prerequisites to this study.

Agricultural engineers are frequently called upon to teach service courses to dairy industry, food industry, and other non-engineering students associated with processing. Such a course can be composed from the list of subjects mentioned before, the subjects being treated from the standpoint of selection, operation, and maintenance rather than design.

The Future — Some Observations

The engineer, and particularly the research engineer, may be reluctant to predict future events in the absence of explicit supporting data. Even though I am a research engineer and data pointing up the future of agricultural process engineering are not plentiful I believe some pertinent observations can be made.

With labor costs increasing and the availability decreasing, everything we can do to improve the effectiveness of labor or replace it with machines will benefit the farmer through added income and the consumer through higher quality at lower prices. Data from the Yearbook of Agriculture shows that the labor of corn production decreased from 34.5 man-hours per year-acre in 1910 to 16.6 in 1950. The reduction in labor for wheat production for the same period was 16.8 to 4.8 man-hours and for all crops from 14.4 to 7.3 man-hours. This reduction in labor requirements is due mainly to the application of engineering principles to crop production requirements. Comparable reductions in processing which requires heavy labor outlays would probably result if organized concerted studies were undertaken. Elec-

tronic fruit and egg sorting, the pipe line milker, picking conveyors for vegetables, the increasing use of mechanical materials handling procedures, wider application of work simplification principles to farm and local processing, the orchard fruit grader are evidences of actual or pending improvements in the labor phase of processing.

Why pay high transportation charges on feathers, hides, and viscera to be removed from poultry and animals used for meat, on the water to be removed from grain, peanuts, raisins, prunes, hops, hay which is to be dried, on the skins, seeds, and other residues removed from fruit and vegetables during a canning process, on trash and foreign seed to be removed from grain and seed stocks? Why ship grain out of a community when it will probably be shipped back in a mixed animal feed? Farm or local processing can reduce transportation charges which will benefit the producer or consumer or both.

Why produce low-grade hay or grain when mechanical drying will produce a high-grade product even under adverse weather conditions? Why sell second-quality milk or eggs when prompt cooling will insure a high-quality product? Why sell apples, potatoes, grapes, pears now when refrigerated storage will permit them to be held for better markets? Properly applied agricultural processing principles can improve the economic worth of a farm product thus increasing the net return.

Why discard the residue from a fruit or vegetable canning operation, cull seed, corn cobs, nut hulls when they can be processed into fertilizer or animal feed.

The recent economic squeeze on agriculture which is due, among other things, to a reduction in farm prices, higher labor costs, and higher freight and other transportation charges can be eased, I believe, by producing better final products at less cost, by doing as much of the processing on the farm or locally as possible, and by using the by-products as effectively as possible. Agricultural processing engineering can help toward this end.

The area of agricultural processing engineering seems to be developing into a specific technical field which can be differentiated from the four presently recognized fields on the basis of the boundaries of the area, the problems, the work objectives, and training required. I am convinced that contributions to agriculture comparable to those by agricultural engineers in the divisions of structures, power and machinery, rural electrification, and soil and water will result if agricultural processing engineering is kept in mind as a specific area of work when studying agricultural engineering problems. Therefore, in conclusion, I challenge agricultural engineers:

1 To become better informed regarding agricultural processing engineering, its characteristics and possibilities, particularly for the region which you serve.

2 To help incorporate training in processing into student program, specially those unit operations most useful for the region served.

3 To analyze each new problem and use the principles of processing in finding a solution when a processing job is being studied.

Portable Castor Bean Huller

(Continued from page 332)

Statistical analyses using the method of least squares were also made to determine which of the straight line, quadratic, or cubic equations expressed the data the best. The equations were found to be as follows:

$$y_1 = \text{tare horsepower} = 1.86 - \frac{8Z}{10^5} + \frac{6Z^2}{10^8}$$

$$y_2 = \text{hulling horsepower} = 0.42 + \frac{5Z}{10^5} + \frac{46Z^2}{10^8} - \frac{5Z^3}{10^{11}}$$

$$y_3 = \text{total horsepower} = 1.96 + \frac{46Z}{10^5} + \frac{29Z^2}{10^8} - \frac{3Z^3}{10^{11}}$$

where Z = rate of hulling in pounds per hour.

SUMMARY

An 18-in, portable, horizontal disk castor bean huller has been built for research purposes which will hull at least 6750 lb of Cimarron beans per hour. At this rate, 4 to 5 percent of the beans are left unhulled and 1 to 2 percent are broken. These rate and quality figures compare quite favorably with those obtained from 24 and 36-in commercial hullers. A huller of this size and type requires 10-hp power unit for hulling at maximum rate.

Four rubber thicknesses were tested on both the upper and lower disks. It was found that higher efficiency pounds per horsepower-hour and hulling rates were obtained using thick lower (rotating) rubbers and thin upper (stationary) rubbers. Rubber thickness had no apparent effect on quality. The shape of the entrance between the two rubbers through which the beans must pass is believed to have some influence on the performance of the huller and may have distorted the results of rubber thickness investigations.

Two rubber hardnesses (32 and 52 durometer) in each of four rubber thicknesses were tested on the upper disk against a 35 durometer rubber on the lower disk. In every case, higher hulling rates and efficiency were obtained using the 52 durometer upper rubber, that is, a 20 point (nominal) hardness differential between the upper and lower rubbers produced better results than rubbers with no hardness differential.

Ten disk speeds between 350 and 800 rpm were tested to determine their effect on rate, quality, and efficiency. It was found that higher disk speeds produced higher hulling rates, but only at a sacrifice of quality and efficiency.

Two sets of rubbers with different angles of bevel on the lower rubber (16 and 34 deg) were compared at two different disk speeds. The only apparent difference between the two was a higher efficiency when using the 16-deg bevel.

When impellers were added to the rotating disk to force the beans out between the rubbers, an increase in hulling rate of as much as 175 percent was obtained with some sacrifice of quality and no apparent effect on efficiency (pounds per hulling horsepower-hour).

Equipment for Installing Gypsum Moisture Blocks

F. G. Mackaness and R. L. Rowse
Member ASAE

IRRIGATORS have long desired an instrument to tell them when it is time to irrigate. Accurate knowledge of prevailing moisture conditions is important in order to facilitate proper timing and amounts of supplemental water.

During the past few years, a number of new techniques and methods have been developed for measuring soil moisture. Among these the electrical-resistance method, employing the use of the plaster of Paris block, has proven to be not only reliable but a method that may be suited to use by the farmer.

To facilitate installation of the gypsum blocks, the following described equipment (see accompanying composite drawing) and technique have been developed by the Portland General Electric Co., Portland, Ore.:

A steel plate, notched on two sides so that it may be laid in a row crop without injuring seedling plants, is placed on the ground. The steel bar is driven through the slot in the center of the plate to the depth at which the lowest block is to be placed. All measurements are made from the bottom edge of the steel plate to the block centers. All tools are marked to make depths of each installation accurate and simple.

The 1,000-lb test hoist shown is attached to the steel bar by means of the clevis arrangement. The bar is then lifted vertically out of the hole. Care should be taken to prevent further enlargement of the hole during removal.

The tamper is used to check the depth, and a block is then inserted into the holder of the block inserter. The block inserter has a plunger which serves to eject the block. The inserter and block are then thrust down to the desired depth. While holding the plunger still, the block holder is raised and the entire device withdrawn gently, leaving the block in the ground at the desired depth.

A measured volume of pulverized subsoil is poured into the hole and tamped. The sheet metal funnel is then inserted to the bottom of the hole and dry bentonite to form a ½-in layer is dropped through the funnel. (The purpose of the bentonite layer is to prevent formation of a water column in the backfill. The funnel, of course, prevents lining the walls of the hole with bentonite.) A second measured volume of soil, just sufficient to fill the hole to the base of the next block when tamped, is introduced. The entire process is repeated until all blocks are installed.

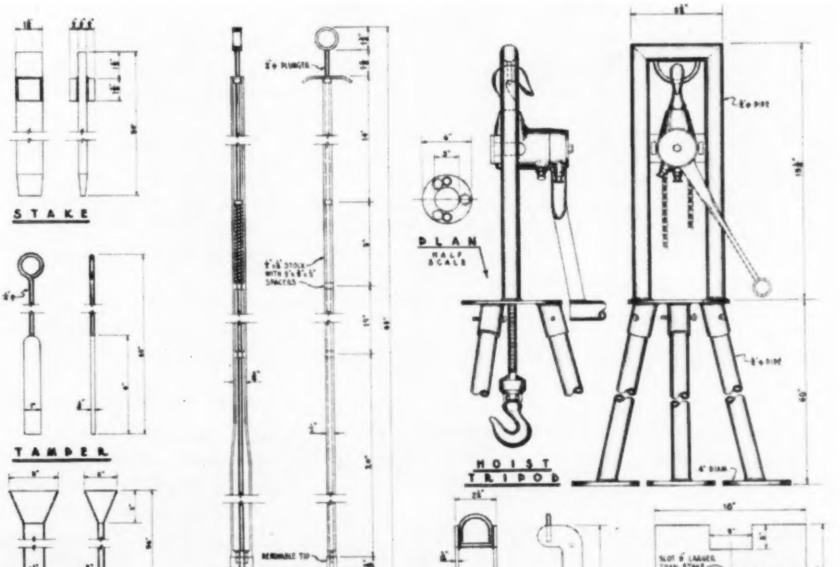
With a little practice, a string of seven blocks can be completely installed in approximately 15 minutes.

The size of the steel bar will be determined by the block size and depth of installation. This particular equipment has been designed for a series of seven gypsum blocks, each measuring ½ x 1¼ x 2½ in, with the individual leads from each block terminating at a Jones plug. It was generally used for installing blocks at 6-in intervals to a depth of 42 in.

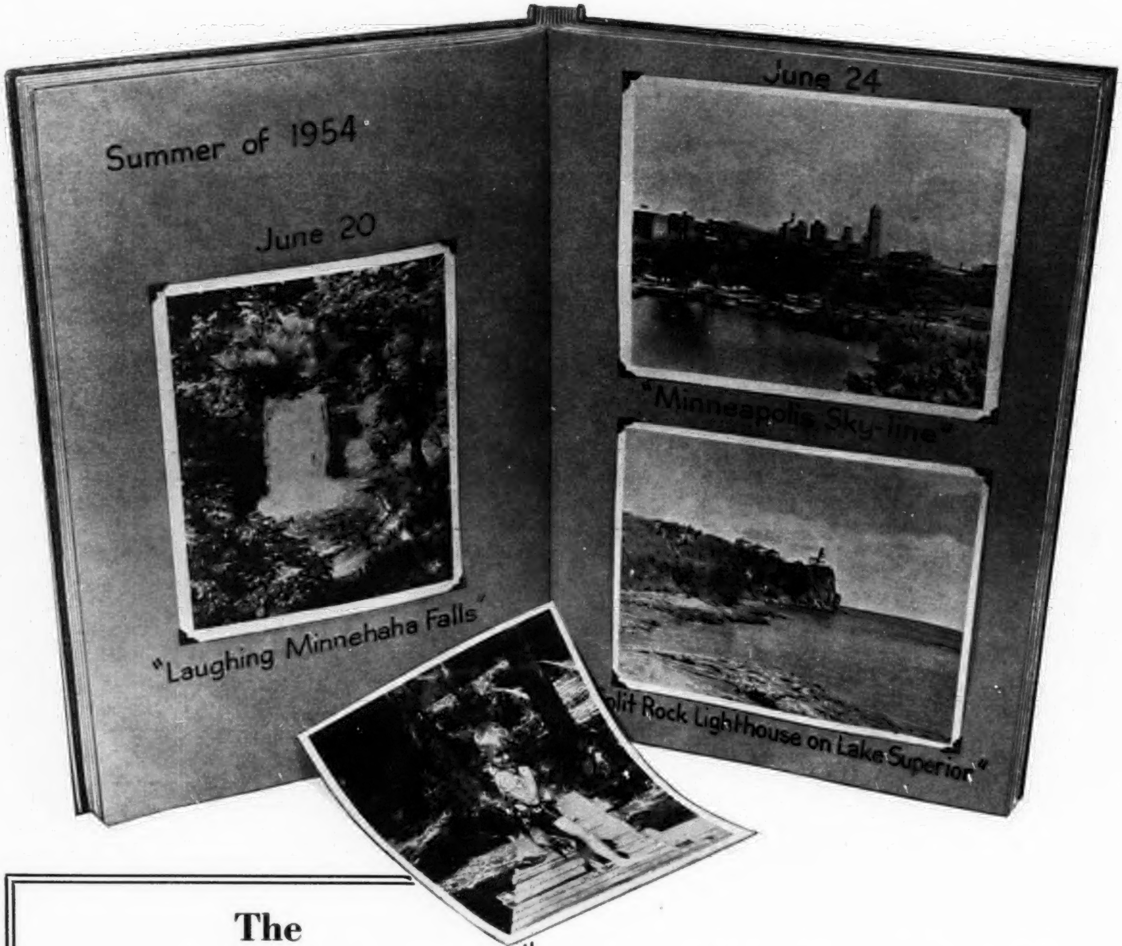
This technique proved entirely satisfactory for the 1953 soil moisture studies. However, a completely new block arrangement has rendered this method obsolete.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors—F. G. MACKANESS and R. L. ROWSE—are, respectively, agricultural consultant and agronomist, Portland General Electric Co., Portland, Ore.



Composite drawing of the various items of equipment used for installing gypsum moisture blocks



The ASAE meeting to remember *Minneapolis*

JUNE 20-23

THE VACATION MECCA of the Midwest is the backdrop for this year's ASAE June meeting being held on the University of Minnesota campus.

From the deluxe buffet supper on Sunday right on through the traditional banquet, there's a 4-day action-packed schedule to delight you and your family. Morning and afternoon sessions will bring you up-to-the-minute on technical developments in agricultural engineering. Take your choice of field trips to Minnesota Mining and Manufacturing Co., Minneapolis-Moline, Minneapolis-Honeywell Regulator Company or the St. Anthony Falls Hydraulics Laboratory.

For the ladies, there are field trips to the Betty Crocker Kitchen (General Mills), the Creamette Co., and Munsingwear. An excursion on the river boat Donna Mae will take them on a scenic trip along the Mississippi.

A Children's Party promises fun for the youngsters. Also, baby sitters will take charge of the little ones when Mom's off on trips.

After the Meeting, maybe you'll want to see the wonders of Minnesota's North country. Grand weather, great lakes, fresh water fish of every specie, and fine resorts will make your family vacation memorable. Drive the beautiful North Shore Drive, see the world's greatest open pit iron mine on the Cayuna Iron Range, and see the Indians and Itasca State Park.

So make your reservations right now for this year's ASAE meeting in Minneapolis. It's the meeting to remember!

NEWS SECTION

1954 ASAE Annual Meeting Program

THE date of June 20 will see agricultural engineers converging on the University of Minnesota campus for the 47th Annual Meeting of the American Society of Agricultural Engineers.

There will be only one general session, Tuesday afternoon, June 2, and four half-day periods available for division sessions. Time for division programs on Tuesday forenoon has been shortened by scheduling the hours before 10:00 a.m. for committee meetings and special programs. The ASAE Annual Dinner will be held on Tuesday evening to enable those to attend who may find it necessary to leave immediately following the division sessions on Wednesday. The Farm Equipment Institute dinner for students is scheduled for Wednesday noon.

College Division sessions will be held concurrently with those of the technical divisions on Monday and Tuesday forenoons for all with a primary interest in teaching, extension, and research.

Entertainment features include a buffet supper at 6:00 p.m., Sunday, followed by entertainment at 8:00 p.m.; a family supper outing Monday evening beginning at 5:30, and the annual dinner, Tuesday evening at 6:45.

An attractive program of additional entertainment for ladies and children has been arranged.

Coffman Memorial Union will be the headquarters and center of activities. Most of the sessions and social functions will be held there.

Committee and special meetings scheduled for the 8:30 to 10:00 period Tuesday forenoon include the extension agricultural engineers, Committee on Surface Drainage, Committee on Agricultural Processing, Committee on Feed Handling, and the student group. The extension and agricultural processing sessions in particular will be open.

An open forum on effective extension methods will be featured in the extension meeting.

ASAE Meetings Calendar

May 14 and 15 ALABAMA SECTION, McLester Hotel, Tuscaloosa, Ala.

June 20-23—47TH ANNUAL MEETING, University of Minnesota, Minneapolis

August 24-26—NORTH ATLANTIC SECTION, University of Vermont, Burlington

October 14 and 15—PACIFIC NORTHWEST SECTION, Davenport Hotel, Spokane, Wash.

December 6-8 — WINTER MEETING, Edgewater Beach Hotel, Chicago.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

A program of short papers arranged for the agricultural processing program will include "The Dozer-Apron Yardage of Corn," by K. A. Finden, Green Giant Co.; "Development of an Automatic Machine to Detect Green Rot in Shell Eggs," by K. H. Norris, A. W. Brandt, and J. D. Rowan, U.S. Department of Agriculture; "Some Engineering Factors Affecting the Efficiency of a Milk Homogenizer Valve," by C. C. Loo, Carnation Co.; and "Heated Air Crop Drying with a Moderate Amount of Heat," by Edgar S. Downs, Lennox Furnace Co.

C. K. Otis, chairman of the Committee on Local Arrangements, will call the general session to order at 1:30 p.m. on June 22. John Ransom, Minneapolis-Moline Co., will address the Society on a subject not yet announced. This will be followed by the President's Annual Address, by Edwin W. Tanquary, International Harvester Co. A third feature will be presentation of the winning paper in the ASAE Student Paper Award competition.

At the end of this program, following a short recess, the Annual Business Meeting of the Society will be convened.

Additional tours will be arranged for those who can extend their stay through Thursday, June 24. Opportunity will be provided to indicate a choice of tours. Transportation will be provided at cost.

FARM BUILDINGS RESEARCH CONFERENCE GROUP

Shown Above during their conference at Beltsville, Md., March 9, are members of the ASAE Farm Structures Research Conference Committee and representatives of farm structures research work in the U.S. Department of Agriculture. Front row, left to right: S. S. De Forest, Ortie La Voy, J. R. McCalmont, S. A. Witzel, E. G. Molander, E. G. McKibben, C. H. Jefferson, C. F. Kelly, F. B. Lanham and R. H. Driftmier. Back row, left to right: Lynn Myers, Price Hobgood, G. R. Mowry, H. J. Thompson, T. E. Long, H. L. Garver, W. V. Hukill, J. R. Dodge, H. E. Besley, S. P. Lyle, and Wallace Ashby

POWER AND MACHINERY PROGRAM

The program being arranged by the Power and Machinery Division will feature harvesting at its opening session beginning at 9:30 a.m., Monday, June 21. The first paper on the program will present results of research work at the University of California on harvesting legume seed and will be presented by P. R. Bunnelle, student engineer, John Deere Waterloo Tractor Works, with L. G. Jones, associate specialist in agronomy, University of California, as junior author. Joseph K. Park, agricultural engineer, U.S. Department of Agriculture, will present the results of research work in South Carolina on harvesting small grass and legume seed crops. The concluding paper of the session will report results of an engineering study of wheat harvesting and storage in Ohio and will be presented by William H. Johnson, assistant professor of agricultural engineering, Ohio State University.

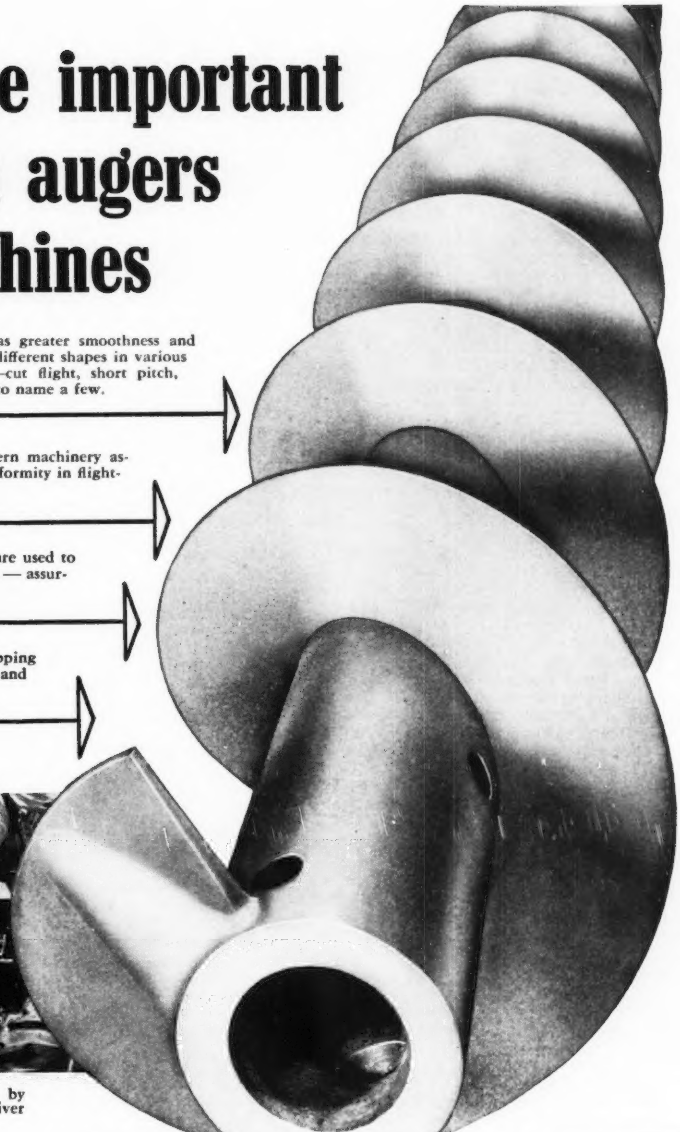
The program arranged for the forenoon session on Tuesday, June 22, at which George M. Eveleth, chief engineer, Rock Island Works, J. I. Case Co., and chairman of the Power and Machinery Division, is to preside, will open with a paper by T. H. Morrell, chief engineer, and H. K. Dommell, supervisor of experimental engineering, Charles City, Iowa, Work of The Oliver Corporation, titled "Thinking Ahead of Tomorrow in Tractor Engine Design." This paper will be followed by a symposium with the general title "The Effects of Improper Inflation on Farm Tires." Four speakers will discuss different aspects of this subject. P. J. Forrest, U.S. Rubber Co., will open the discussion. Tire problems of the modern tractor is the subject of the contribution by J. M. Hooper of the B. F. Goodrich Co. Ralph W. Sohl, The Goodyear Tire and Rubber Co., will talk on effects of inflation pressure on traction and tread wear of tractor tires, and the subject of effect of inflation pressure on rear tractor tire life will be dealt with by George F. Mullin, Firestone Tire and Rubber Co. These four contributions will be followed by general discussion of the subject.

At the third power and machinery session on Wednesday forenoon, June 23, George M. Eveleth, division chairman, will again preside, and the program will open with a paper on the development of application equipment for anhydrous ammonia by C. L. Hedman, Shell Chemical Corp. This will be followed by an engineering paper on the application of torque amplifiers to farm tractors by Henry Ferguson, Tractor Works, International Harvester Co. Results of research work on harvesting corn with a combine will next be discussed by George E. Pickard, professor of power and machinery at the University of Illinois, and the program of the session will conclude with a report of a survey on research on agricultural aviation by Mr. Pickard and G. F. Sanders, chairman and member, respectively, of the ASAE Committee on Agricultural Aviation.

In the afternoon A. J. Schwantes, University of Minnesota, will preside over a panel discussion, being arranged by local agricultural engineers, on harvesting and processing of forage crops. W. A. Swenson, Minneapolis-Moline Co., will be the panel leader. Additional participants will be an-

(News continued on page 342)

CHECK these important differences in augers for farm machines

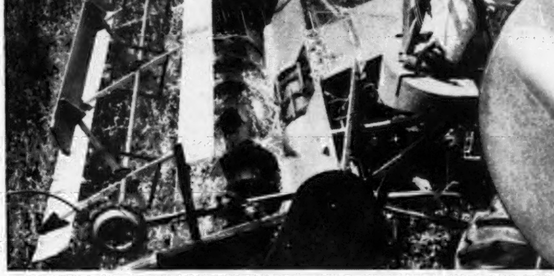


✓ **ONE-PIECE HELICOID FLIGHTING** has greater smoothness and strength. Link-Belt also builds many different shapes in various metals to meet your specific needs—cut flight, short pitch, ribbon flight, tapering, double flight to name a few.

✓ **UNIFORM PITCH** — Specialized modern machinery assures accurate forming, producing uniformity in flighting curvature.

✓ **ONLY SPECIALLY SELECTED STEELS** are used to meet Link-Belt's rigid specifications — assuring smooth flight surfaces.

✓ **STRAIGHTNESS** is checked before shipping and extra care is taken in handling and loading.



Complete auger for this harvester-thresher is furnished by Link-Belt. Opposed flights move cut grain to center, deliver it to pick-up conveyor.

LINK-BELT gives you sound engineering plus accuracy of manufacture for top performance

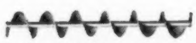
WHEN you make a Link-Belt auger part of your farm machine, you can be sure of efficient operation plus long-life, low-maintenance service. Link-Belt builds augers for every purpose—gathering cut grain back of the sickle bar, conveying, elevating, spreading, feeding, mixing or digging.

Each can be engineered for your specific requirements . . . each will provide long-lasting efficiency, thanks to Link-Belt's unequalled accuracy of manufacture. Let your nearby Link-Belt sales representative point out the many important differences in augers to you. And be sure he gives you a copy of Book 2289, covering Link-Belt's regular line of conveyor screws and components.

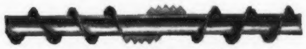
Typical examples of Link-Belt Augers

Sectional-flight

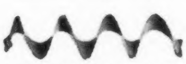
Helicoid flight with end, plain beater



Helicoid flight auger



Opposed flights with center saw-tooth beater



Unmounted Helicoid flighting

LINK-BELT

FARM MACHINE AUGERS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N. S. W.; South Africa, Springs. Representatives Throughout the World.

13,384

NEWS SECTION

(Continued from page 340)

nounced. Open discussion will follow the panel presentations.

FARM STRUCTURES PROGRAM

Reports on some recent research will be featured on the Monday morning program. N. H. Curry, chairman of the Farm Structures Division, will preside. Subjects and speakers to be heard are "Calorimeter Studies of Growing Chicks and Laying Hens," by H. L. Garver and Hajime Ota, Agricultural Research Service, U.S. Department of Agriculture; "Use of Sol-Air Temperature Measurements in Summer Animal Shelter Studies," by G. L. Nelson and Geo. W. A. Mahoney, Oklahoma A & M College; "Rigid Pillar Construction," by L. W. Bonnicksen, Oregon State College; and "Pressures in Grain Bins Resulting from Increases in Grain Moisture," by A. C. Dale and R. N. Robinson, Purdue University.

Committee reports are to be presented at the Tuesday morning session, with S. A. Witzel, University of Wisconsin, presiding. Four subcommittees of the ASAE Committee on Farm Structures Research are to report as follows: "Farm Building Materials Handbook"—A. C. Dale, Purdue University; "Farm Building Equipment, Design and Space Requirements" — A. H. Hemker, General Electric Company; "Recruiting and Training Farm Structures Personnel"—J. Roberts, State College of Washington; and "Farm Structures Research Needs and Statistics"—B. C. Reynolds, Office of Experiment Stations, U.S. Department of Agriculture. A "Report of the Research Conference Committee to the Farm Buildings Research Section, U.S. Department of Agriculture, by Ortie La Voy, Weyerhaeuser Sales Co., is next on the program. This will be followed by "A Regional Project Outline for Farm Structures Research," by C. K. Otis, University of Minnesota, chairman North Central Regional Committee 23.

C. H. Jefferson, vice-chairman of the Farm Structures Division will preside at the Wednesday morning session on "Farm Building Design and Selection." Matters to be reported and considered are "Training in Functional Design," by J. C. Wooley, University of Missouri; "Design Procedures in a Regional Planning Service," by D. G. Jedele, Midwest Plan Service; "The Design of Prefabricated Farm Buildings," by Tappan Collins, Stran-Steel Div., Great Lakes Steel Co.; and "Assisting the Farmer in Building Selection," by R. E. Spelts, Jr., Spelts of Nebraska, Inc.

"New Developments in Building Fabrication" will be the theme for the final session Wednesday afternoon. Chairman Curry will preside. Scheduled contributions are "Prefabricated Plywood Farm Buildings," by G. M. Peterson, University of Nebraska; "Aluminum Covered Pole Frame Buildings," by Charles Walte, Jr. Reynolds Farm Institute; "Packaged Laminated Wood Frame Buildings," by Fred W. Kasler, Rilco Laminated Products, Inc.; and "Precast Concrete Floor Systems," by Mike Trebtoski, Dox-Block Co.

RURAL ELECTRIC PROGRAM

This opens on Monday morning with a varied program and W. J. Ridout, Jr., vice-chairman of the Rural Electric Division, presiding. Scheduled subjects and speakers are "Effects of Certain Electric Treatments on the Growth of Young Chickens," by D. T. Kinard, University of Georgia; "Performance and Electrical Load Characteristics of 5-hp Motors and Grinders," by M. W. Forth, Deere and Co., and E. W. Lehmann, University of Illinois; "Magnetic Devices to Remove 'Tramp Metal' from Livestock Feed," by W. H. Knight, University of Idaho; "New Developments in Farm Wiring Materials," by Glen Rowell, Fire Underwriters Inspection Bureau; and "How the Rural Electric Division Is Organized," by E. T. Swink, chairman.

Features for the short session Tuesday morning are "Electrical Demand and Diversity Characteristics of Iowa Farms," by L. B. Altman, Jr., Agricultural Research Service, U.S. Department of Agriculture and Iowa State College; "Treatment of Farm Pond Water for Domestic Use," by E. R. Daniel, Oklahoma A & M College; and "Power Supplier Cooperation in Providing In-Service Training for Vocational Agricultural Teachers," by W. R. Black, Virginia Electric and Power Co., and E. T. Blackwell, Mecklenburg Electric Cooperative. Division chairman Swink will preside.

Animal environment and feed handling problems of special interest to agricultural engineers are to be featured on the Wednesday morning program, with Vice-chairman Ridout again presiding. "Environment and Its Relation to Animal Health," by W. A. Junnila, Agricultural Research Service, is to be the opening presentation, followed by "Progress in Drying and Self-Feeding Chopped Hay," by K. K. Barnes, Iowa State College; Long Distance Blowing of Grain and Ground Feed," by R. W. Kleis, University of Illinois; and "New Farm Crop Handling Equipment That Is Commercially Available," by Vernon C. Belt, Belt Corp.

Features of the closing session Wednesday afternoon will be presentations on "Investigations Using the Heat Pump for Farm and Home Applications," by Chester P. Davis, Jr., Agricultural Research Service, U.S. Department of Agriculture and Kansas State College; "Use of Feed Mixer as a Grain Drying Chamber," by C. Ivan Branton, Alaska Agricultural Experiment Station; "Effect of Dielectric Heating and Cathode Rays on the Germination and Growth of Wheat," by Leo H. Soderholm, Agricultural Research Service, U.S. Department of Agriculture and the University of Nebraska; and "How the Crop Dryer Manufacturers' Association Is Serving Agriculture," by James B. Moore, Pierson-Moore Co.

SOIL AND WATER PROGRAM

Each of the four technical groups in the Soil and Water Division will offer a program during one of the four periods available for technical sessions.

The Hydrology Group will lead off on Monday morning. To provide an ideal atmosphere for this session, and to relate it to the afternoon inspection trip period, it is to be held at the St. Anthony Falls Hydraulic Laboratory of the University of Minnesota, on Hennepin Island, a few minutes walk or drive from the meeting headquarters. Those who expect to attend this session are urged to clear the registration desk Sunday afternoon or early Monday morning, and head for the River in time to be on hand when the session starts at 9:30 a.m.

Items on the program include "Latest Developments in Water Conditioning," by Wm. G. Buchinger of the Detroit Edison Co.; "Use of Evapo-Transpiration Data in Determining Available Water Supply of Drainage Basins," by Harry F. Blaney, Agricultural Research Service, U.S. Department of Agriculture; "The Influence of Inlet Design on Culvert Capacity," by Lorenz G. Straub, director, St. Anthony Falls Hydraulic Laboratory; and "Use of Relative Infiltration Indices in Computing Runoff," by Roy G. Andrews, Soil Conservation Service, U.S. Department of Agriculture. Howard Matson, chairman of the Hydrology Group, will preside.

Box lunches are to be made available at the Laboratory so that all who wish to do so may make the most of this opportunity to visit the Laboratory, examine its facilities, and talk with the engineers stationed there. An inspection of the Laboratory in the afternoon will amount to a continuation of the morning program.

Irrigation is to be featured in the short session time available on Tuesday morning. Wayne D. Criddle, chairman of the Irrigation Group, is to preside. He has arranged a program including presentations on "Sprinkler Pattern Studies in South Dakota," by J. L. Wiersma, South Dakota State College; "Improving Estimates of Irrigation Water Requirements for Short Periods of Time," by John T. Phelan, Soil Conservation Service, U.S. Department of Agriculture; "Good Irrigation Is Vital to the Control of Mosquito Problems," by Marshall B. Rainey, U.S. Department of Health, Education and Welfare; and "Development of Irrigation Guides for North Central States," by Keith Beauchamp, Soil Conservation Service, U.S. Department of Agriculture.

Attention will be centered on drainage in the Wednesday morning session. John G. Sutton, chairman of the Drainage Group, has arranged a five-feature program as follows: "Recommendations for Installation of Drain Tile Subject to Freezing, Alkali, or Acid Conditions," by P. W. Manson and D. G. Miller, University of Minnesota; "Improving Drain Tile Practices Through Contractors Associations," by Kenneth W. Hotchkiss, drainage contractor, Clarks Grove, Minn.; "Drainage Investigation Methods and Equipment for Planning Drainage of Irrigated Lands," by Geo. B. Bradshaw, Soil Conservation Service, U.S. Department of Agriculture; "Progress in Preparing Drainage Recommendations by Soil Types," by Keith Beauchamp and Guy Fasken, Soil Conservation Service, U.S. Department of Agriculture; and "Result of Questionnaire Pertaining to Research Needs," by John R. Davis, Michigan State College.

A Symposium on "Engineering Erosion Control Practices" has been arranged by John R. Carreker, chairman of the Erosion Control Group, for the Wednesday afternoon program. Contributions scheduled are "Teaching Soil and Water Conservation in Professional Engineering, Service, and Short Courses," by Carlisle Cobb, Jr., University of Georgia; "Research in Erosion Control Practices," by Louis B. Nelson, Agricultural Research Service, U.S. Department of Agriculture; "The Present Status and Future Outlook for the Field Program of Engineering Erosion Control Practices," by J. J. Coyle, Soil Conservation Service, U.S. Department of Agriculture; and "Evaluation of Gully Control Structures in Southwestern Wisconsin," by Neal E. Minshall, Agricultural Research Service, U.S. Department of Agriculture.

COLLEGE DIVISION PROGRAM

For those more interested in educational than in technical subject matter phases of agricultural engineering, the College Division will hold sessions on Monday and Tuesday mornings. "Teaching Students of Agriculture and Majors in Vocational Agriculture" will be the Monday morning theme. Frank W. Peikert, vice-chairman of the

(Continued on page 344)

NEWS SECTION

(Continued from page 342)

College Division, will preside. "Some Differences in Objectives for Farm Mechanics Courses" will be presented by C. F. Albrecht, Michigan State College. This will be followed by reports on "Trends in Commercial Instruction Books, Bulletins and Visual Aids," in four specific fields. Those dealing with tractors and machines will be reported by Lee H. Ford, International Harvester Co.; lubrication and fuels, C. N. Hinkle, Standard Oil Co. of Indiana; farm electrification, A. H. Hemker, General Electric Co.; and Farm Buildings, E. D. Anderson, Stran-Steel Div., Great Lakes Steel Corp. Laboratories are the next item for consideration, "A Tractor Engine's Laboratory," by J. J. Sulek and L. W. Hurlbut, University of Nebraska and "A Rural Electrification Laboratory," by Elmer Daniel, Oklahoma A & M College, are scheduled contributions.

Research techniques will be emphasized in the Tuesday morning session, with L. W. Hurlbut, chairman, presiding. "Statistical Principles in Planning Experiments," by Paul G. Homeyer, Iowa State College, and "Application of Experimental Stress Analysis in Agricultural Engineering," by J. K. Jensen, John Deere Waterloo Tractor Works, are the scheduled papers.

STUDENT GROUP PROGRAM

The Students program will open Monday morning with a "Welcome to Minnesota" by A. M. Flikke, chairman of the Local Committee on Student Activities. Don Meyer, president of the National Council of ASAE Student Branches, will preside and call next for remarks on "Student Activities in the Society" by C. L. Zink, chairman, ASAE Committee on Student Branches. Dean Miller, secretary of the National Council of Student Branches will call the roll of Branches. A talk on "Selling—Opportunity Unlimited,' by J. W. Simpson, International Harvester Co., is next on the program. This is to be followed by presentations of the winning papers in the ASAE Student Paper Award Competition. The session will conclude with the "Annual Report on Student Affairs from ASAE Headquarters," by Frank B. Lanham, Secretary, ASAE.

On Tuesday morning Charles Overman, 1st vice-president, National Council of Student Branches, will preside over a session devoted to reports, discussion, and nominations. Richard Russell, 2nd vice-president of the National Council will "MC" the reporting and discussion of Student Branch Activities during the past year. The meeting will then be declared open to nominations for officers of the National Council for 1954-55.

Wednesday noon is the time set for the Student Group Dinner given by the Farm Equipment Institute. It will be followed at 2:00 p.m. by the concluding student session. At that time M. E. Weakley, chairman, ASAE Committee on FEI Trophies, will present a review of the 1954 FEI Trophies Competition. Time has been allowed for considerable discussion on the competition. Election of officers for 1954-55 will be the closing feature of the session.

Morrison New Chairman Iowa-Illinois Section

CHARLES S. MORRISON, chief engineer, product development department, Deere & Co., Moline, Ill., was elected chairman of the Iowa-Illinois Section of the American Society of Agricultural Engineers at the annual meeting of the Section held at Moline on April 23. He succeeds C. K. Beeman, assistant product engineer, J. I. Case Co., Burlington, Iowa. Two new vice-chairmen of the Section were also elected at this meeting: Marlin E. Weakly, engineering department, East Moline Works, International Harvester Co., and Roy E. Harrington, assistant project engineer, product development department, Deere & Co.

Edward G. Rowlett, district engineer, The Torrington Co., was elected the new secretary of the Section, and Gerald W. Berryhill, junior engineer, Rock Island Works, J. I. Case Co., was elected the new treasurer.

A new record for attendance was set at this meeting of the Section—and perhaps of any ASAE section meeting—with a total registration of 215, a 20 percent increase over the attendance at its preceding annual meeting.

The formal program for the meeting was preceded by plant tours of the John Deere Planter Works in Moline and the John Deere Malleable Works at East Moline.

Following the plant tours the group

T. L. Burkland *(left)*, Deere & Co., and G. P. Phillips *(center)*, International Harvester Co., display exhibits of shell molding to ASAE President E. W. Tanquary *(right)* at the Society's Iowa-Illinois Section meeting at Moline, Ill., on April 23

listened with keen interest to two talks on the shell molding process by G. P. Phillips of the International Harvester Co. and T. L. Burkland of Deere & Co. This was followed by a panel discussion, with Carlton Zink of Deere & Company as moderator, which provided helpful information to college students interested in employment opportunities in the farm equipment industry, and which also attempted to answer questions put by students attending the meeting. A large group of students in agricultural engineering from both Iowa State College and the University of Illinois were in attendance.

The Section dinner followed the program, and after the dinner the group was addressed by ASAE President E. W. Tanquary, staff engineer, Farm Implement Division, International Harvester Co. The meeting concluded with a business session which included the election of officers.

ASAE Iowa-Illinois Section officialdom at recent Section meeting. *Left to right*, R. R. Roth, E. G. Rowlett, C. S. Morrison, M. E. Weakly, C. K. Beeman, R. E. Harrington, C. L. Zink, and C. W. Olson. Morrison and Beeman are, respectively, chairman and retiring chairman. Weakly and Harrington are the new vice-chairmen, Rowlett the new secretary, and Roth, Zink, and Olson the new nominating committee

Mack Jones New Chairman Mid-Central Section

MACK M. JONES, head, agricultural engineering department, University of Missouri, Columbia, was elected chairman for the ensuing year of the Mid-Central Section of the American Society of Agricultural Engineers held April 2 and 3 at St. Joseph, Mo. Three new vice-chairmen of the Section were also elected as follows: J. A. Bondurant, irrigation research engineer, agricultural engineering department, University of Nebraska; Keller Cordon, agricultural field representative, Portland Cement Assn., and D. D. Smith, project supervisor, soil and water conservation research, U.S. Department of Agriculture. The new secretary-treasurer of the Section is L. T. Wendling, Jr., extension agricultural engineer, Kansas State College.

About 80 members and guests of the Section attended the meeting, and included in the meeting this year, in addition to the regular program, was a tour of the Quaker Oats Milling and Feed Mfg. Company's plant at St. Joseph. The tour was followed by a bowling match which is apparently becoming a regular feature of the meetings of this Section.

At the business session of the meeting, the Section voted to meet again at St. Joseph for its 1955 meeting, which is scheduled for the dates of April 1 and 2. The program committee set up for the 1955 meeting will include E. A. Olson, G. E. Fairbanks, J. G. Andros and M. L. Esmay. H. F. Baton, assisted by Webb Embrey, has been appointed to look after local arrangements for the 1955 meeting.

(News continued on page 346)

NEWS SECTION

(Continued from page 344)

Florida Section Holds First Annual Meeting

PROGRESS in the application of engineering to the subtropical agriculture of Florida was marked by the first annual meeting of the Florida Section of the American Society of Agricultural Engineers, at Jacksonville, March 19 and 20.

Ralph Lambert, chairman of the committee on arrangements, opened the Friday afternoon program, which included remarks by T. E. Hancock, Section chairman; a welcome to Jacksonville by Haydon Burns, mayor; a paper on concrete for farm utilities structures by Hugh R. Roberts, Portland Cement Association; a discussion of the relationship between agricultural engineering and soil and water conservation by U. S. Allison, Soil Conservation Service, USDA; a talk on student branch activities by Francis J. Krist, president, Florida Student Branch of ASAE, and a tour of the St. Regis paper mill, in charge of D. Smith, Hester Plow Co.

A smorgasbord dinner the same evening featured an address by James W. Simpson, manager of sales operations research, International Harvester Co. Jack O'Donnell, International Harvester Co., was master of ceremonies.

John M. Johnson, secretary of the Florida Section, presided over the Saturday forenoon program. Following are the scheduled papers and speakers: Progress of the new agricultural engineering building of the University by Thomas Skinner, University of Florida; progressive development of an implement by J. F. Zich, Ford Motor Co.; growth and advancement of electrification in Florida by Claude H. Smith, Florida Power and Light Co., and progress of kenaf fiber production by Hiram D. Whittemore, USDA fiber research laboratory.

Bud Moss New Chairman Georgia Section

BUD S. MOSS, manager, rural division, Georgia Power Co., Atlanta, was elected new chairman of the Georgia Section of the American Society of Agricultural Engineers at the Section meeting in April. He succeeds James W. Harwell, soil conservationist, U.S. Soil Conservation Service. James L. Shepard, agricultural engineer, Georgia Coastal Plain Experiment Station, Tifton, was elected new vice-chairman of the Section. Carlisle Cobb, Jr., was elected the new secretary of the Section.

Headquarters for the meeting held on April 9 and 10 was at a motor court near Midway, Ga. The first session was held at the Fleming quarters of the Tidewater Conservation Experiment Station where members of the staff, including G. N. Sparrow, J. F. Thornton, Harry Ukkelberg, and L. W. Robinson addressed the group, following which there was a tour of the field plots of the station. This was followed by a visit of the old Henry Ford Plantation at Richmond Hill where the group observed lettuce harvesting and processing as well as ditching and diking on fresh water marsh land.

The high light of an evening session on April 9 was the presentation of a citation to R. H. Driftmier, chairman, division of agricultural engineering, University of Georgia, and a past-president of ASAE, in recognition of his twenty-five years of service to agricultural engineering in Georgia and the South.

The meeting closed with a sumptuous fish dinner on the evening of April 10.

(News continued on page 348)

NEWS SECTION

(Continued from page 346)

J. T. Reid Heads West Virginia Section

JAMES T. REID, instructor in agricultural engineering, West Virginia University, Morgantown, was elected the new chairman of the West Virginia Section of the American Society of Agricultural Engineers in a recent election of officers. He succeeds Fred P. Oliver of the Union Insulating Co. Other officers elected include a new vice-chairman, Russell H. Gist, University of West Virginia, and a new secretary, James L. Darby, agricultural engineer, Appalachian Electric Power Co., Point Pleasant.

ASAE Now Associate Member of ASEE

THE American Society of Agricultural Engineers was recently elected to associate institutional membership in the American Society for Engineering Education. ASAE Council voted to apply for such membership on recommendation of the Executive Committee of the College Division and officers of the Agricultural Engineering Division of ASEE.

This grade of membership is held by a distinguished list of other engineering and technical societies and industrial organizations. It helps to identify ASAE prominently as an organization having a major interest in engineering education and gives the Society representation on the Engineering Colleges Research Council and the Engineering College Administrative Council of ASEE. Appointment of ASAE representatives on those bodies is expected to be made in the near future.

Hawaii Section Considers Crop Drying

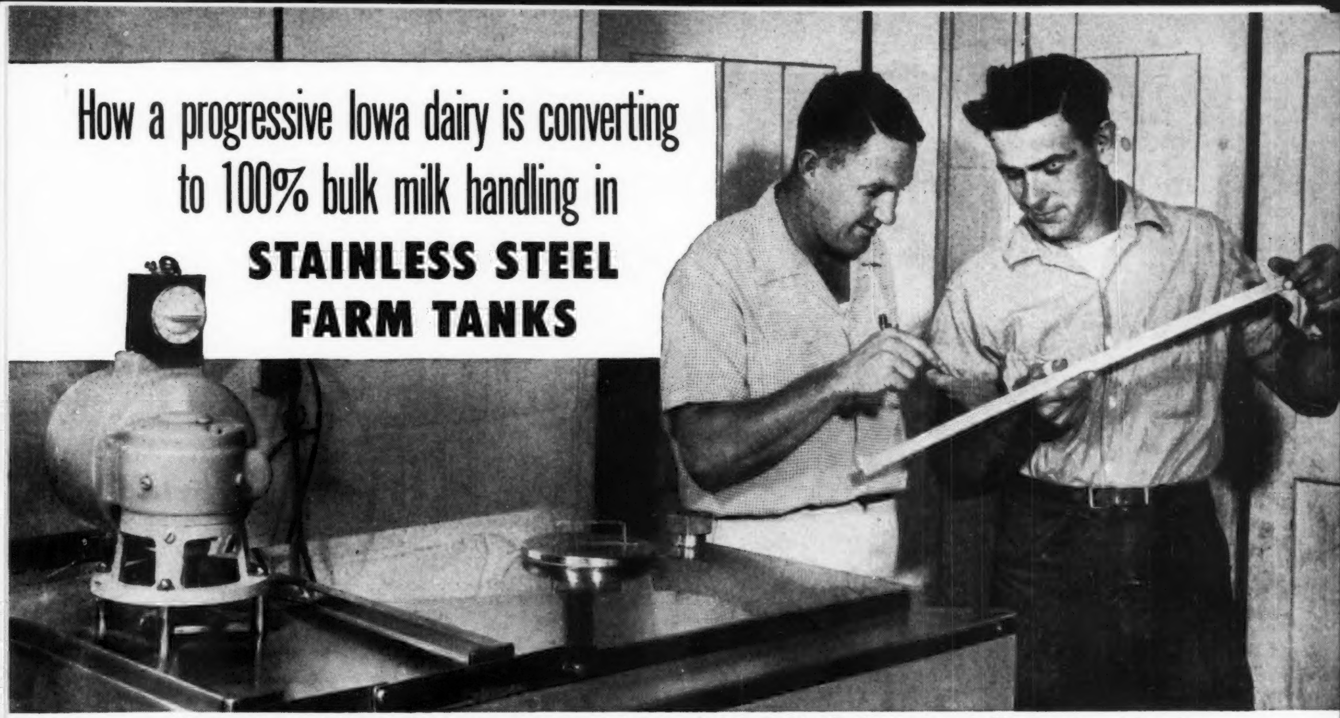
DEHYDRATION was featured in a meeting of the Hawaii Section of the American Society of Agricultural Engineers, on April 7, at the University of Hawaii. Loyd Blomquist, chairman, introduced first Donald Kinch, University of Hawaii, who talked on the dehydration of feed products. He discussed the present uses and sources of supply of protein concentrates. He suggested that alfalfa, koa haole, and pigeon peas might be grown locally to reduce the 8 to 10 million dollars which we are sending to the mainland for feed products annually. He then explained why high protein feeds must be dehydrated in order to preserve the carotene content. This was followed by discussion of the problem encountered and machinery needed to set up and operate a commercial dehydrator. His talk was closed by description of the dehydrator presently being installed on the University farm at Waimanalo.

Robert Strohman, University of Hawaii, talked on drying coffee and rice. He told about the conventional method of drying coffee on open platforms, and then described two types of mechanical driers, the rotating drum driers which are patterned after those used in other coffee-producing areas, and the bin-type driers introduced two years ago by the Hawaii Agricultural Experiment Station. There are seven rotating and twenty of the bin type in Kona now. He concluded with a brief description of the Shanzer rice drier which went into operation on Kauai last summer.

William Hole, of the Honolulu cannery of California Packing Corp., spoke on dry-

(News continued on page 350)

How a progressive Iowa dairy is converting to 100% bulk milk handling in STAINLESS STEEL FARM TANKS



Here Farris Biggart, fieldman for Sanitary Farms, and Joseph E. Green, check the Stainless Steel measuring rod. The Green farm at Cascade, Iowa, is one of the Sanitary Farms Dairy's producers that has converted to the bulk milk handling system.

IN August, 1953, Sanitary Farms Dairy, Cedar Rapids, Iowa, launched a program that will eventually see every one of its 340 producers equipped with a Stainless Steel farm tank for bulk handling of milk.

Conversion is going ahead a route at a time and the job will be completed in about a year. Much of the success of the program to date is the result of a careful explanation of the advantages of the bulk handling system to producers by Farris Biggart, Sanitary Farms fieldman.

Mr. Biggart points out that Stainless Steel farm tanks mean a gain of 10 to 30 pounds of milk every pick-up, plus a slight rise in butterfat content. "We find," he says, "a producer is more willing to cooperate when he understands that the bulk handling system means bigger milk checks through increased weight, less heavy hand labor, better quality and great savings in time."

Sanitary Farms Dairy is helping its producers make the change by finding a market for equipment made obsolete by the change to bulk handling. New Stainless Steel tanks are being made available to the producers on a contract basis.

If you would like more information on the bulk handling system, mail the coupon below. Working with our customers who fabricate farm tanks from USS Stainless Steel, we have accumulated much data on the bulk milk handling system. We will be happy to make it available to you.

Joseph E. Green pours milk into the Stainless Steel farm tank while his father, Joseph A. Green, looks on.

Agricultural Extension Section
United States Steel Corporation, Room 4351
525 William Penn Place, Pittsburgh 30, Pa.

Please send me free literature about farm bulk milk equipment. Send information to:

Name..

Title..

Company..

Street..

City................Postal Zone....State............

United States Steel is a steel producer, not a bulk milk equipment fabricator. Your request, therefore, will be sent to manufacturers who fabricate bulk milk equipment for farm use.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · PIPE · TUBES · WIRE
BARS · BILLETS · SPECIAL SECTIONS

4-830-A

UNITED STATES STEEL

NEWS SECTION

(Continued from page 348)

ing pineapple bran. The canneries have been drying pineapple bran for over 25 years with the two-fold purpose of sanitary removal of by-products and increase in the islands' dairy feed supply. Mr. Hole explained how the process had recently been reorganized to provide maximum capacity by adding controls to vary rate of feeding according to outlet temperatures.

Agricultural Engineers Participate in Engineers Conference

MEMBERS of the agricultural engineering department staff at Ohio State University participated in the first annual conference for engineers initiated this spring by the Engineering College of Ohio State University, which was held on May 7 on the University campus. This program featured various aspects of the research work in agricultural engineering and included the following reports: Reel investigations by B. J. Lamp, cylinder investigations by W. H. Johnson, theoretical study of rack motion by P. T. Yarrington and B. J. Lamp, and early harvesting by W. H. Johnson and E. T. Hurst. A talk by R. C. Miller on the role of agricultural engineering concluded the agricultural engineers program.

The conference was opened with a general session at which Dr. Charles F. Kettering was the main speaker. His subject was "Getting Results from Engineering Research."

Each department in the Engineering College presented research programs and held open house throughout the afternoon. In addition to agricultural engineering the following departments participated: aeronautical, ceramic, chemical, civil, electrical, industrial, and mechanical engineering; metallurgical, mining and petroleum engineering; welding engineering; photography; and the school of architecture and landscape architecture.

Agricultural Engineering in ASEE Meeting

"MEETING Needs in Agricultural Engineering Education" will be the theme of a half-day session in the annual meeting of the American Society for Engineering Education to be held at the University of Illinois, June 14-18. The session is sponsored by the Agricultural Engineering Division of ASEE, and is scheduled for Thursday afternoon, June 17.

Orval C. French, chairman of the Division, has expressed the hope that interested agricultural engineers in industry as well as in the colleges and federal employment, will plan to attend this session en route to the ASAE Annual Meeting at Minneapolis the following week.

The session theme will be introduced at a luncheon preceding the afternoon program, with an address on the future needs of engineering education by M. A. Durland, dean of engineering, Kansas State College. At 2:00 p.m. E. W. Lehmann, University of of Illinois, will preside as moderator for a panel discussion, scheduled contributors to which will be W. M. Carleton, Michigan State College, on meeting needs through agricultural engineering curriculums; L. W. Hurlbut, University of Nebraska, on meeting needs through better teaching methods, and Geo. E. Spencer, Purdue University, on meeting needs through better counseling.

A laboratory inspection at 4:00 p.m. will conclude the program.

NEWS OF ASAE MEMBERS

E. L. Hansen, who is engaged in engineering, sales and contracting work on farm structures at Hillsdale, Ill., and who is also district sales engineer for Martin Steel Products Co., is listed in the 1954 edition of "Who's Who in America." Mr. Hansen was a member and farm structures specialist of the Agricultural Engineering Committee to China in 1947 and 1948. He also served four months in 1949 as agricultural engineer in the agricultural group of Overseas Consultants, Inc., in Iran. He is presently serving as a vice-president of ASAE and as a member of the Council.

John A. Kriva has resigned as a layout and design engineer, Main Works, J. I. Case Co., Racine, Wis., to accept a position as project engineer on agricultural applications with the Warner Electric Brake and Clutch Co., S. Beloit, Ill.

Donald B. Curry has resigned as agricultural engineer in the Farmers Home Administration to accept a position as heating and ventilating sales engineer with the Northern Utilities Gas Co., Casper, Wyo.

Paul D. Colbenson, formerly employed as an appraiser-engineer with the Federal Housing Administration is now associated with the Douglas Fir Plywood Assn., Tacoma, Wash., as an engineer on plywood research.

Frank R. Hollopeter, until recently on duty with the armed services, is now employed as a research technician in the research engineering department of the Ford Tractor and Implement Division, Ford Motor Co. at Birmingham, Mich.

Sherwood S. De Forest has been advanced from assistant to associate editor of *Successful Farming*. He will continue to give major attention to agricultural engineering developments of direct interest to farmers.

Charles A. Rollo has resigned as manager of Grimes Tractor and Implement Co., Montgomery, Ala. ,to accept a position with the Tractor and Implement Division, Ford Motor Co., Birmingham, Mich.

Raymond C. Fisher has resigned as harvester engineer at the LaPorte, Ind., works of Allis-Chalmers Mfg. Co., to accept a position in the product planning department of the Tractor and Implement Division, Ford Motor Co. at Birmingham, Mich.

James M. McCurry, formerly electrification adviser to the Meriwhether-Lewis Electric Membership Cooperative in Georgia, is now employed by E. I. duPont de Nemours and Co. as area engineer on construction of the company's Savannah River plant.

R. V. Ramiah, head of the division of agricultural engineering, Indian Agricultural Research Institute, New Delhi, is author of the publication entitled "Buyers Guide for Indian Agricultural Implements," published by the Indian Council of Agricultural Research also of New Delhi. The publication includes a short description of implements and machines manufactured and used throughout India.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Brown, Floyd E.—Extension irrigation specialist, Agricultural Extension Service, Colorado A. & M. College, Fort Collins, Colo.

Byrne, Donald L. — Sales representative, Townsend Co. (Mail) 924 State St., Bettendorf, Iowa

Cobb, Carlisle, Jr.—Assistant professor of agricultural engineering, University of Georgia, Athens, Ga.

Dodson, J. R.—Irrigation specialist, Mathieson Chemical Corp. (Mail) Box 255 Shoemakersville, Pa.

Dyke, Leslie A.—Vice-president in charge of export division, The Oliver Corp., 400 W. Madison St., Chicago 6, Ill.

Feehan, Leonard—Electrical advisor, Cornhusker Rural Public Power District, Columbus, Nebr. (Mail) 2216 18th St.

Floyd, Oscar H.—Irrigation specialist, Russell Daniel Irrigation Co. (Mail) 906 "O" St., Alexander City, Ala.

Hamilton, James S.—Director of agricultural sales, Virginia Electric and Power Co., Richmond, Va.

Karban, Joseph W.—Recently released from U.S. Army. (Mail) RR 1, Waukomis, Okla.

McCall, Floyd—Farmer, inventor. (Mail) PO Box 188, Romoland, Calif.

Mills, Kermit C.—Field agent in agricultural engineering extension, University of Kentucky, Lexington, Ky. (Mail) 132-4 Shawneetown

Nemethy, John J. — Graduate research assistant in irrigation, University of Nebraska, Lincoln 3, Nebr. (Mail) Room 201 Agricultural Engineering Bldg.

Palmer, Melville L.—Research assistant and graduate student, Ohio Agricultural Experiment Station. (Mail) Agricultural Engineering Dept., Ohio State University, Columbus, Ohio

Phelan, John T. — Irrigation engineering (SCS), USDA, Lincoln 2, Nebr. (Mail) 1845 Dakota St.

Sack, Hans W. — Engineering research department, John Deere Waterloo Tractor Works. (Mail) 1021½ Grove, Cedar Falls, Iowa

Smith, Lomax—Secretary, manager, and supervisory engineer, Escondido Cement Products Co., Inc., PO Box 817, Escondido, Calif.

Stewart, Billy R.—Surveyor's helper, Shell Oil Co. (Mail) 1322 N. Graham, Odessa, Texas

Swenson, William E.—Design correlator for various engineering departments, Minneapolis-Moline Co. (Mail) 1436 W. California Ave., St. Paul 13, Minn.

Tessmann, Andrew—Extension agricultural engineer, University of Vermont, Burlington, Vt

Theocharides, Harry E.—Engineer, International Harvester Co., Stockton, Calif. (Mail) 3024A Munford Ave.

Van Valkenburgh, Bryce F. — Chief inspector, Chains, Inc., 13943 Park Ave., Dolton, Ill.

Yaw, Robert W.—Manager of standards department, Ralston Purina Co., 3813 Hiawatha Ave., Minneapolis, Minn.

Transfer of Membership Grade

Baker, Eugene D.—Senior project engineer, New Idea Farm Equipment, Division of Avco Mfg. Co., Coldwater, Ohio. (Mail) 401 N. 2nd St. (Associate Member to Member)

Beeman, Clarence K.—Assistant production engineer, J. I. Case Co., Burlington, Iowa. (Mail) 113 Indian Terrace (Associate Member to Member)

Bittinger, Morton W. — Associate research work in fields of drainage, irrigation and erosion control, Iowa State College, Ames, Iowa. (Mail) Agricultural Engineering Bldg. (Associate Member to Member)

Hutchison, Reed S. — Research associate, Agricultural Marketing Service, USDA. (Mail) Barrow Hall, University of Georgia, Athens, Ga.

Irwin, Ross W. — Assistant drainage supervisor, department of agricultural engineering, Ontario Agricultural College. (Mail) Agricultural Engineering Dept., Iowa State College, Ames, Iowa (Affiliate to Associate Member)

MacCarthy, J. A.—Supervisor, Farm Services Section, British Columbia Electric Co. Ltd., 633 Royal Ave., New Westminster, B.C., Canada (Affiliate to Associate Member)

Sconyers, Jack H.—Territory manager, John Deere Plow Co. (Mail) PO Box 417, Dublin Ga. (Associate Member to Member)

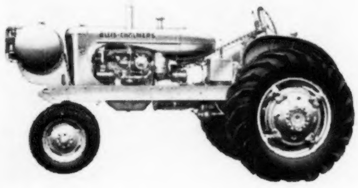
NEW PRODUCTS CATALOGS

Ball-Bearing Pillow Blocks

Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., announces it has in production new, low-cost ball-bearing pillow blocks with pressed steel housings designed for applications where speeds are relatively low and loads are light, also which cost less and give all the advantages of precision antifriction-bearing performance. They are designated Link-Belt Series JPS-200 and are available for shafts from ⅞ to 1¼ inches in diameter. They are easily installed by slipping the inner ring onto a shaft and locking it into position. Slotted bolt holes permit easy lateral adjustment. A synthetic rubber lip-type seal, integral with the bearing, provides maximum sealing efficiency to retain the lubricant, and to exclude dirt. No further lubrication is necessary as the bearings are lubricated for life. Additional information is provided in the new Link-Belt folder No. 2517, which includes load ratings and dimensions of pillow blocks.

LP Fuel Conversion

Allis-Chalmers Mfg. Co., Tractor Div., Milwaukee, Wis., announces a liquid petroleum fuel conversion for its WD-45 tractor equipped with the power-crater engine. This equipment is installed at the factory and complies with all state fire underwriters codes for safe operation in the field. A combination carburetor is used for either gasoline or LP fuel. The fuel tank is mounted in front of the radiator, and the outward appearance of the tractor is not altered nor is the operator's vision impaired.



Sweet Corn Picker

International Harvester Co., Chicago, Ill., announces that after several years of field tests it is releasing a new two-row, tractor-mounted sweet corn picker. The feature of the picker is the combination of a new type of straight-fluted rolls working in combination with stripper plates above the rolls.

Stalks are pulled through the stripper plates by the rolls, causing the ears to be snapped off at the butts, with minimum damage to milk-filled kernels.

Tractor-Mounted Hillside Plow

International Harvester Co., Chicago, Ill., announces a new tractor-mounted plow with which furrows of uniform width can be turned with the tractor going in either direction along a steep hillside. It is called the McCormick No. 22 hillside plow and utilizes the fast-hitch method for quick connection to the Farmall Super C tractor. A lever-controlled shifting device allows the operator to shift the plow to right or left, as required to counteract downhill drift.

NEW BOOKS

Machinery's Handbook, by Erik Oberg and F. D. Jones. Fifteenth edition, Holbrook L. Horton, editor. Buckram, 1911 pages, 4½ x 7 inches. Illustrated and indexed. The Industrial Press (148 Lafayette St., New York 13, N. Y.) $9.00.

This handbook emphasizes information needed in the design and production departments of manufacturing plants and job shops, and in trade and technical schools. It has been brought up to date as to current standards and latest design and manufacturing practice. The table of contents lists 136 section headings, but the work is further thumb indexed for ready reference to 14 main headings as follows: Log tables, trig tables, mechanics, strength of materials, gearing, bolts and screws, screw threads, limits and gages, small tools, speeds and feeds, steels and alloys, motors, weights and measures, and index.

Fresh Water from the Ocean, for Cities, Industry, and Irrigation, by Cecil B. Ellis. Cloth, xi+217 pages, 6 x 9 inches. Illustrated and indexed. The Ronald Press Co. (15 E. 26th St., New York 10, N.Y.) $5.00.

Sponsored by the Conservation Foundation, this work does an excellent job of bringing together and evaluating tried and suggested approaches to the technical and economic problems of producing fresh water from the ocean for adjacent water-short areas. The idea of desalting sea water has wide appeal, the problems are far from solved, and the author and sponsors hope this book may encourage additional fruitful research. With this in mind special emphasis is placed on the basic matter and energy relationships common to all methods of sea water conversion. Chapter headings are: The Problem, Types of Separation Methods, Energy Costs, Long-Range Force Systems, Actions on the Container, Sieve Processes, Distillation with Conventional Fuels, Distillation by New Heat Sources, Chemical Surface Methods, The Sale of By-Product Chemicals, A 1000-Mgd Electric Membrane Plant and Conclusions.

NEW BULLETINS

Methods and Costs of Loading Apples in the Orchard in the Pacific Northwest, by Earl W. Carlson et al. Marketing Research Report No. 55 (January, 1954) U.S. Department of Agriculture (Washington, D.C.). Reports research showing advantages and disadvantages of various methods of handling in terms of cost, labor requirement, delay in getting apples into storage, and damage to the fruit. In general the net advantage was on the side of equipment and systems requiring the smallest number of operations per box.

Cement and Concrete Reference Book, 1954. Portland Cement Association (Chicago 10, Ill.) Concise information on the industry, the Association, and uses of portland cement and concrete for paving, construction, housing, farm applications, conservation, precast products, and special uses.

Labor-Saving Concrete Dairy Barns. Portland Cement Association (Chicago 10, Ill.) A guide to construction for stall barns, loose housing and milking barns with brief notes on stalls, alleys, pens, mangers, gutters, cow trainers and barn cleaners, insulation, ventilation, light required, feed room, silos, hay storage, milkhouse, paved yards, concrete masonry walls, floors, bedded areas, feeding area, milking and milk handling area, feed and bedding storage, young stock housing, milking rooms, milkrooms, and making quality concrete. Readers are referred to their state colleges for specific plans, and to local health inspectors or dairy plant fieldmen for further information on sanitary requirements.

Hard Surfacing for Farm Equipment. Lincoln Electric Co. (Cleveland 17, Ohio). An 8-page reprint from "How to Repair and Build Farm Equipment with Arc Welding," giving brief instructions on electrode and powder methods as applied particularly to soil-working parts.

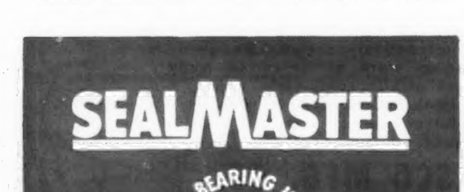
Handling Silage and Concentrates for Beef Cattle in Drylot, by R. N. Van Arsdall and Thayer Cleaver. Illinois (Urbana) Extension Circular 714 (January, 1954). Points out feed-handling practices which minimize labor and investment costs per beef animal fed.

Economic and Functional Characteristics of Farm Dairy Buildings, by R. N. Van Arsdall, D. B. Ibach, and Thayer Cleaver. Illinois Agricultural Experiment Station (Urbana) Bulletin 590 (November, 1953). A study of dairy buildings with a view to needs and possibilities of remodeling to facilitate adoption of modern methods and equipment for more efficient production and improved sanitation.

Strength of Auto-Nailer Assembled Skids of Green and Dry Lumber, by E. George Stern. Virginia Polytechnic Institute, Wood Research Laboratory (Blacksburg) Bulletin No. 12 (December, 1953). The nailing machine and type of nail used are reported to produce stronger assemblies than hand nailing with a comparable size and number of nails.

you *have* to understand the Farmer's Problems!

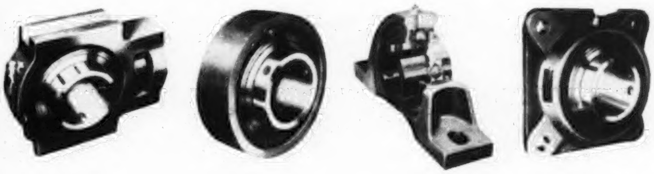
This man is a SEALMASTER Sales Engineer! He is representative of SEALMASTER Sales Engineers throughout the agricultural industry who work hand-in-hand with farm implement manufacturers on field assignments. His job? . . . to solve power transmission problems wherever they exist . . . help raise the standards of product performance in both newly developed and old established machinery through utilization of *exactly* the right bearing units. This close cooperation with the farm machinery manufacturer has brought about the development of better, *more efficient use of tractor power* and reduced machine maintenance due to bearing failure. It has resulted in a friendly relationship between SEALMASTER and the manufacturer which has carried on down through his dealer organization and his own satisfied customers. Whatever your bearing unit need or problems, be sure to discuss them with SEALMASTEF



For your copy of SEALMASTER Catalog 454 call the SEALMASTER sales office in your city or write:

SEALMASTER

BALL BEARING UNITS



TAKE-UP UNIT | CARTRIDGE UNIT | PILLOW BLOCK | FLANGE UNIT

SEALMASTER BEARINGS A Division of STEPHENS - ADAMSON MFG. CO., 69 Ridgeway Ave., Aurora, Ill.

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—1953—DECEMBER—O-454-544, 465-545, 479-547. 1954—JANUARY—O-488-549, 491-550, 494-551. FEBRUARY—O-19-602. MARCH—O-65-603, 66-604, 67-605, 68-606, 73-607, 62-608, 74-609, 75-610, 75-611. APRIL—O-90-613, 98-614, 106-615, 102-616, 116-617, 134-618.

POSITIONS WANTED—1953—NOVEMBER—W-404-74, 426-75. DECEMBER—W-395-76, 431-78, 396-79, 405-80, 425-81, 423-84, 453-85, 451-87. 1954 — JANUARY — W-456-88, 490-90, 484-91. FEBRUARY—W-5-102, 20-103, 24-105, 25-106, 45-107, 46-108. MARCH — W-16-110, 56-112, 54-113, 29-114, 37-116, 64-117, 78-118. APRIL —W-86-119, 84-120, 101-121, 96-122, 93-123, 109-124, 124-125, 125-126, 107-127.

NEW POSITIONS OPEN

MANAGER for Midwest regional area promotion of aluminum building products for farm use. Age 30-40. BS deg required, MS deg preferred. Approximately 5 to 10 yr experience in farm structures and public relations work. Some extension experience desirable. Willing to travel 50 percent of time. Must be dynamic, aggressive, and have good presentation. Good opportunity financially within range of this position. Line of promotion to assistant director and director, or through sales department. Salary $500 plus per month. O-131-619

AGRICULTURAL ENGINEER for research in power and machinery, with special attention to forage crop and labor-saving equipment, and some work on heating equipment for curing tobacco, in a land-grant university in a south central state. BS deg in agricultural engineering or equivalent, with good foundation in fundamentals, plus MS deg or additional training in mechanical or electrical engineering. Must have strong interest in research. Actual experience in research in farm power and machinery field desirable. Opening effective now. Salary open, depends on training and experience. O-149-620

AGRICULTURAL ENGINEER, extension specialist in farm power and machinery, for adult and 4-H Club work in a north central state. BS deg or higher in agricultural engineering, or equivalent. Experience in extension or other work in power and machinery field. Good health, ability to work with people, interest in writing and speaking. Twelve-month basis, 26 days annual leave. Federal retirement plan. Position now open. Normal opportunity for advancement. Salary open, depends on experience and training. O-150-621

SOIL CONSERVATIONIST (1) and AGRONOMISTS (5) for civilian technical aid with Army in Korea. Age, under 57. BS deg or higher. Five years or more of well-rounded work experience in field, including 2 yr in specialized work. Single men preferred. Married men acceptable if families willing to remain in USA. Must be adaptable to rugged conditions. One-year tenure. Only these specific openings available. Openings in related work not foreseen in near future. Salary, soil conservationist, GS-13, $8,360 plus 25 percent differential—$10,450; agronomist, GS-12, $7,040 plus 25 percent differential—$8,800. O-151-622

AGRICULTURAL AND DEVELOPMENT ENGINEERS (2 each) for field study, design, improvement, and sales promotion on new items of farm equipment; and for training and work with present development engineers in industrial products division of established manufacturer. East Coast location. Age 25-35. BS deg or higher in agricultural or mechanical engineering. Dairy farm background and practical experience in handling farm equipment. Usual personal qualifications for engineering in industry. Excellent opportunity for advancement. Right man could follow products from initial design through to successful manufacture and marketing. Limited travel. Sick benefits and retirement plan. Bonus system. Salary $350 to $600 per mo to start, depending on experience and ability. O-155-623

AGRICULTURAL ENGINEERING ADVISORS, field agricultural engineers, and mechanical technicians, for work with Point 4 program in Pakistan, on agricultural engineering phases of agricultural program, national and provincial workshop projects, and development of training programs in field and shop equipment and development of equipment. BS deg with major in agricultural engineering. Experience 10 yr in education, field testing or development, shop work in industry, extension, vocational agriculture, mechanical phases of soil and water management, or applications of research in agricultural engineering. Must enjoy working with others, be willing to give careful consideration to the ideas of others, and able to work under extremely adverse conditions. Salary, GS-12, 13 or 14 rating. O-108-624

AGRICULTURAL ENGINEER, research assistant, for full-time research in farm power and machinery or farm structures first year; research ¾, teaching ¼-time thereafter, in an eastern land grant university. BS deg in agricultural engineering, or equivalent. Some industrial experience desirable but not required. Interest in research and teaching, ability to work and get along with others. Excellent opportunity for advancement and for work toward MS deg. Starting date July 1. Salary $3600 to start. O-162-625

AGRICULTURAL ENGINEER, instructor and junior engineer or assistant professor and assistant engineer rating, for teaching and research in soil and water field, in a western state college. Half time college teaching, half on irrigation or drainage research. BS or MS deg in agricultural engineering, or equivalent, with strong background in engineering fundamentals. Field engineering experience in irrigation or drainage one year for instructor and junior engineer rating, two years and advanced degree for assistant rating. Usual personal qualifications for college teaching and research. Opening effective about July 1. Send personal data, grade transcripts, references, and record of experience with letter application. One month vacation. Salary $4200—4900 for instructor; $4600—5400 for assistant, depending on qualifications. O-173-626

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for design, development, research, sales or service in power and machinery or soil and water field, with industry or public service, in West, Southwest, or Midwest. Married. Age 28. No disability. BS deg in agricultural engineering, 1951, New

(Continued on page 360)

Index to Advertisers

Personnel Service Bulletin

(Continued from page 358)

Mexico A & M. Minnesota farm background. One summer with SCS before graduation. Field engineer in Central America with United Fruit Co., 2 yr. Sales engineer on portable irrigation systems at present. War enlisted service with Navy 2 yr. Available June 1. Salary $4200 min. W-122-128

AGRICULTURAL ENGINEER for sales or service work in power and machinery or product processing field, with manufacturer or processor in Southwest or Southeast. Married. Age 25. No disability. BS deg in agricultural engineering, 1951, University of Illinois. Manufacturing planner on liaison work between large manufacturer and various subcontractors. War noncommissioned service in Army Air Force 1½ yr. Available on reasonable notice. Salary open. W-146-129

AGRICULTURAL ENGINEER for design and development in power and machinery, with industry or public service, anywhere in U.S.A. Single. Age 24. Vision corrected. BS deg in agricultural engineering, 1951; MS deg in agricultural engineering expected Sept. '54, Virginia Polytechnic Institute. Farm background. Design engineer at Army Biological Laboratories 22 mo., including 20 mo in military service. Available Sept. 20. Salary open. W-128-130

Professional Directory

RATES: 80 cents per line per issue; 40 cents per line to ASAE members. Minimum charge, five-line basis. Uniform style setup. Copy must be received by first of month of publication.